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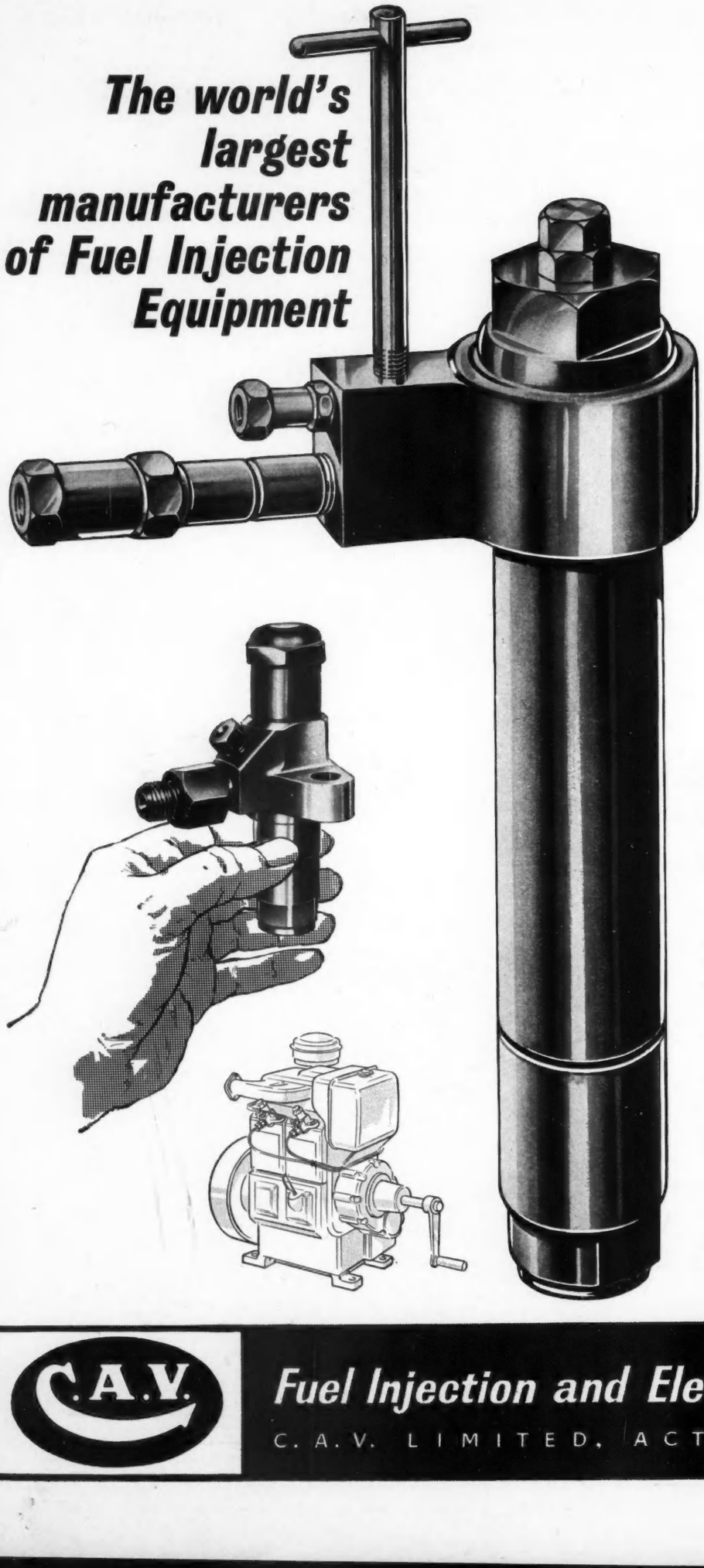

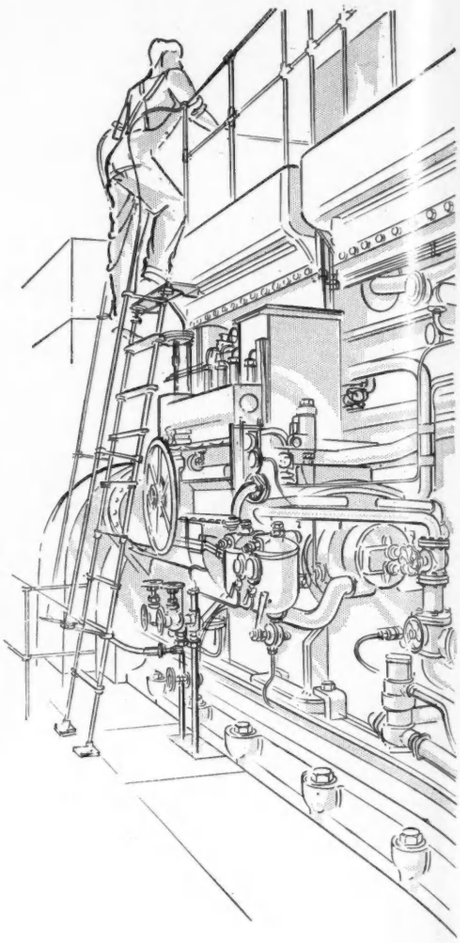

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ENGINEERING

An Illustrated Weekly Journal

Vol. 177 No. 4607 MAY 14, 1954

Leading Article
High-Voltage Transmission 609

Principal Articles
Rolls and Royce 612
Groups within Industry 614
Ailsa Shipbuilding Company 616
Institution of Naval Architects: Ship Performance and Model Prediction 618
New Metals in Engineering 620
The Physics of the Ionosphere 621
British Naval Gas Turbines 622
Traversing Mechanism for Pyrometer and Pitot Tube 624
3,200-kV Impulse Generator at the National Physical Laboratory 625
A 200-ton Spring Balance 626
From Market Research to Production: The Development of "Challenger" Tractors 627
Radioactive Isotopes 630
Ultrasonic Drilling Machine for Hard Materials 632
Engineering Exhibits at the B.I.F. 633
Gas Turbine for Ships' Emergency Generator Drive 636

Weekly Survey
Investment Allowance and Machine Tools 610
Locomotives in Ireland 610
Plutonium Production at Windscale 610
Export Merchants and Engineering Exports 610
National Industrial Fuel Efficiency Service 611

Letters to the Editor
Napier "Nomad" Engine 611
Drawings in "Engineering" 611

Personal 613

Business Changes 613

Obituary
Colonel H. J. Wellingham 613

Contracts 614

Book Reviews
Cold Formed Machine Bolts and Hexagon Nuts 617
Densening and Chilling in Foundry Work 617

Books Received 617

Trade Publications 617

Labour Notes 639

Launches and Trial Trips 640

Notices of Meetings 640

News
National Society of Master Patternmakers 611
Heavy-Water Atomic Reactor 612
Mechanised Farming 612
Awards by the Royal Aeronautical Society 614
Trade with Sweden 614
The Junior Institution of Engineers 615
Materials Handling Demonstration 615
Marine Radar Equipment 615
Institute of Metals: Annual Dinner 615
The World's Shipbuilding 616
Film on Corrosion 616
Film on Combustion 621
Rimutaka Tunnel "Holed Through" 623
Information Wanted on Rockwell Scales 632
Road Research Laboratory 638
The Iron and Steel Institute 640

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HIGH-VOLTAGE TRANSMISSION

THE fifteenth International Conference on Large Electric Systems (CIGRE), which opened in Paris on Wednesday last and continues until Saturday, May 22, is being attended by over 1,200 persons. These participants are considering 127 papers, covering the field with which this body is concerned. They have therefore been set a considerable task, although not one that is greater than the importance of the subject merits. The matters to be dealt with include alternators, transformers, circuit-breakers, cables and overhead lines, substations, protection, stability, surges, telephonic and radio disturbances, as well as extra-high voltages. Although it would be too much to say that all the communications presented are of equal value, or even of equal general interest, they give a good idea of the progress that has been made during the 30 or more years that this conference has been in existence.

At the same time, there is some indication that a pause for reflection is occurring. In dealing with the proceedings at the conference two years ago we were able to record the progress that was being made in the use of voltages between 275 and 400 kV, especially in Sweden and France and to a less extent in the United States and Russia. This year, only the United States and Japan are directly represented by papers dealing with this question, although Mr. G. Jancke and his assistants present an interesting account of the use of 380-kV series capacitors in Sweden. This records that the 380-kV system in that country is being rapidly extended and will ultimately transmit about 5,500 MW over an average distance of 500 miles. On such a system the amount of power carried per line is much influenced by stability conditions, which can be improved by the use of series capacitors; and in this way reduce transmission costs by some 15 per cent. With the increasing distance between the generating plant and the point of utilisation these results should be of interest in countries other than that of their origin.

While Sweden's electrical system is mainly based on the use of water power, the Ohio Valley Electric Corporation's scheme for supplying 15,000 million kilowatt-hours per annum to the gaseous-diffusion plant of the Atomic Energy Commission in the Portsmouth area will depend on steam. According to the paper presented by Messrs. P. Sporn and V. M. Marquis, two stations, one at Kyger Creek (1,000 MW) and the other at Clifty Creek (1,200 MW) on the Ohio River, are being erected for this purpose. At both, steam will be generated at 2,000 lb. per square inch and 1,050 deg. F. and re-heated to the same temperature. It will be supplied to turbo-alternators with individual outputs of just over 217 MW. The generator voltage, 15·5 kV, will be stepped up to 380 kV in a bank of three 80-MVA single-phase transformers from which power will be fed into the 400-mile system of the Corporation and its subsidiary the Indiana-Kentucky Electric Corporation; and thence to Portsmouth. The scheme forms part of the general power system in the area and shows how the demands for electric power are increasing on the other side of the Atlantic. An associated scheme is that of the American Gas and Electric Service Corporation, which will also operate at 330 kV. The problems associated with its establishment are described in a paper by Messrs. F. A. Lane, J. H. Kinghorn and F. M. Porter.

Turning to Japan, Mr. H. Mori deals with the 275-kV Shin-Hokurika system over which power is transmitted from a water-power station at Narude some 150 miles to Hirakata on the outskirts of Osaka. The performance of this line, which is the first in Japan to be operated at so high a voltage, has been quite satisfactory and further developments in the same field are to be expected.

All these papers deal with the transmission of alternating current. In fact, a significant feature of the programme is the almost entire absence of papers describing schemes of direct-current transmission. It is true that a communication by Mr. K. Nagai gives an account of an investigation which has been conducted for transmitting power in this way between the mainland of Japan and its islands. This, however, deals mainly with the rectifier-inverter problem.

Such questions may, however, be considered to be more of future than of immediate importance. Indeed, the greater part of the proceedings consists of account of steps that are being taken in a variety of directions to consolidate the ground that has been won in the field of rather lower voltages. They are not less valuable for that reason, especially as the international character of the conference gives an opportunity of discussing many differences in current practice. British delegates have played a leading part in recording what is being done in this country. Of particular value, too, are the study reports on various aspects of the main subject. These represent a good deal of work which is carried out between the biennial conferences. Engineers engaged in transmitting electric power at high voltages have therefore no reason to complain of lack of technical information on this subject.

Weekly Survey

INVESTMENT ALLOWANCE AND MACHINE TOOLS

Representations have been made to the Chancellor of the Exchequer by the British Association of Machine Tool Merchants against what they describe as the inequity and ambiguity in the section of the Finance Bill 1954 dealing with the investment allowance. They are concerned at the differing treatment accorded to new and secondhand equipment in the Bill. It will be recalled that the allowance does not extend to secondhand machinery or to plant which does not represent new investment.

The association consider that in its present form the Bill discriminates against small firms which are accustomed to re-equipping themselves with secondhand machinery. They further point out that when the plant is sold or fully depreciated there is always an advantage of 20 per cent. in the investment over initial allowance owing to the balancing charge. The association cannot accept the view that purchase of new plant represents net investment while investment in secondhand plant does not. They see also administrative difficulties in differentiating between new equipment, defined in the Bill as "unused and not secondhand," and secondhand defined in the Bill as "bought after use by previous owner."

None of these points is exclusive to the machine tool industry and the association is, of course, interested in selling new machines as well as secondhand ones; but the merchanting trade (and the Government as well) are very much concerned at the moment in finding a market for some £30 million of Government-owned Continental machine tools which are not now required for the modified version of the defence programme. The association and those who think like them on this point are probably on stronger, and certainly less complicated ground, if they argue the case on the question of marketing rather than on accountancy and productivity. The ascertainment of whether a given piece of new equipment compared with a corresponding secondhand item is more of a net investment or conducive to more production is an issue on which accountants and economists might argue indefinitely. But in an industry where the secondhand trade amounts to at least 75 per cent. of the trade in new machine tools (an analogy with the car industry springs to mind) and where special marketing difficulties in disposing of Government stock are imminent, the need to sustain an active secondhand market is clearly of paramount importance. Here is the critical argument.

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LOCOMOTIVES IN IRELAND

Railways, it has been said, are a luxury which Ireland cannot afford. It is certainly imperative that railways in that country – whether in the northern or southern part – be operated with maximum efficiency if they are not to be liabilities or, indeed, cease to exist. The fact is that to-day the more difficult the economic situation of railways in any part of the world the greater the need for an enterprising outlook. In recent years such an outlook has been a prominent feature of the policies of the Chief Mechanical Engineers of both the Great Northern Railway of Ireland and Córas Iompair Eireann in the south. Both these concerns have turned to Diesel traction on a large scale; the former added 20 Diesel railcars to its stock in 1950 and 1951, whereas the latter, which has had a 915-h.p. Diesel-electric locomotive since 1950, by now placing an order with the Metropolitan-Vickers Electrical Company for 94 Diesel-electric locomotives (as reported on page 613) has become the first railway in Britain or Ireland to embark on the large-scale use of Diesel power for main-line purposes.

The number of Diesel-electric locomotives now ordered represents 21 per cent. of the existing locomotive stock. On this basis, the order must be unprecedented so far as large railways are concerned. Undoubtedly a factor which has influenced this decision is the question of availability of fuel. If fuel must be imported – as is the case with steam coal in Ireland – the advantages of oil become enhanced. The only indigenous fuel found in quantity in Southern Ireland is peat – or, as the Irish call it, turf. Although no report has as yet been published it is known that for some time Mr. O. V. S. Bulleid has been carrying out tests with turf burning. Turf has been used in many countries, including America and – most surprisingly – even in Britain in the early days of railways. Often it has been employed as a makeshift, as in Sweden when coal imports were rendered difficult by war, and in addition to being employed in its natural state after drying, it has been used in powdered form and compressed blocks.

Although there are certain disadvantages accruing from its use, some of the earlier experiments produced unsuspected results, among which was increased boiler life due to the absence of sulphur, soot, etc. The conclusions reached from earlier tests were that to burn peat satisfactorily the firebox must be specially designed and constructed. A broad and short grate with closely-spaced bars gave the best results, and the bars – due to the reduction in flame – required lifting towards the firebox crown. A thin fire was essential, and to prevent it from being lifted up the chimney, modifications of the blast arrangements were required. It is hoped that in due course the results of the tests carried out in Eire will be published as they should be of value to locomotive engineers in countries where peat is available.

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PLUTONIUM PRODUCTION AT WINDSCALE

The main object of a visit arranged by the Atomic Energy Commission last week was to inspect the methods adopted at the Windscale works, Sellafield, Cumberland, for the production of plutonium. Interest, however, tended to be "stolen" by a distant view of the Calder Hall site, on which the first industrial atomic power station in this country is being erected. Here work on one of the two nuclear reactors, which will "burn" natural uranium, is well advanced and progress is also being made with the associated power plant. The reactors in this project which, it is hoped, will be completed in about 18 months, will be cooled by carbon dioxide under pressure, and the hot gas will subsequently be led to heat exchangers with which the steam-raising plant will be associated.

Details of the two piles at the Sellafield, or Windscale, works were given by Sir Christopher Hinton in the James Clayton Lecture, which was delivered before the Institution of Mechanical Engineers on Friday, February 26, and an illustrated abridgement of which was published on page 313 *ante*. It may be recalled, however, that each is a monolithic concrete structure, which has been erected on a mat of the same material, 10 ft. thick and 200 ft. long by 100 ft. wide. The piles themselves consist of a central core of graphite blocks, which are pierced by horizontal channels. In these channels are laid rows of uranium cartridges sealed in aluminium cans, the whole assembly being surrounded by a graphite reflector. As the central core becomes highly radioactive during operation it is covered by a wall and roof of concrete several feet thick, protection against heat being provided by a steel lining. Operation is controlled by 24 boron steel rods, which enter the core horizontally. Of these rods, 20 are ganged together to provide coarse control and the remainder are driven separately for fine control. In both cases the drive is electrical and is controlled from a central position. In addition, there are 16 shut-down rods, which are normally held out of the pile by electromagnets, but fall by their own weight when the excitation is cut off in emergency. Cooling is effected by fans which blow air through the piles and thence through filters into the 415 ft. stacks. Other filters are installed in a gallery some 30 ft. from the top of the stacks.

The irradiated uranium slugs produced in the pile are discharged into a deep water channel and then into a pond, where they are left until some of their radioactivity has been lost. They are then dissolved in nitric acid and treated with a solvent, which separates the plutonium from the other material, the resulting solution being purified and finally converted into plutonium metal. The depleted uranium solution is purified and returned to the Springfield factory for re-utilisation. All these operations are conducted with careful regard to the hazards not only from radioactivity, but from chemical poisoning, fires and explosions.

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EXPORT MERCHANTS AND ENGINEERING EXPORTS

Exports of engineering products during the first quarter of 1954 were well above the 1953 level, and accounted for the highest proportion of total exports recorded since the war. The monthly average value of engineering exports rose from £79 million in the first quarter of 1953 (£82 million for the first half of the year) to £87 million in the first quarter of 1954. The proportion for which they accounted of total exports in the same periods were 29 per cent. and 39 per cent. respectively. Much of the improvement, however, was due to a vast expansion in the export of household appliances – refrigerators, vacuum cleaners, radio receivers, etc. – as well as aircraft and cars. This was largely the result of an improvement in economic conditions in Australasia and Scandinavia.

The major worries of the exporters of machinery expressed during last year concerning increased foreign competition remain, and may well become more acute during the next few months. The *Times*' recent export survey – conducted through its overseas correspondents – revealed weaknesses in the marketing techniques of British exporters in most countries, which must in a good many cases be a serious handicap. Most of these are said to be due to insufficient knowledge of local conditions that lead to a general failure to follow local practice, particularly in respect of trade literature, correspondence and tendering. This obviously will apply much more to the small and medium-size companies than to those who are large enough to have personal representation or, in some cases, local factories and offices. One specific and widely applicable criticism was the "careless choice of sales channels." To some extent, this is the result of the attempt of a large number of companies to handle export business themselves without adequate knowledge. They were very successful during the many years of sellers'

market that followed the war, but are now finding it difficult to compete, particularly under conditions in which first rate intelligence and close personal contacts with each market are needed to obtain inquiries.

The National General Export Merchants' Group have recently published a booklet entitled "Export Selling" which suggests that export merchants may well provide at least some of the necessary close contact with markets, coupled with the experience accumulated, for many of the members, over a century's export trading. About one third of the Group's 650 members export engineering products and claim the necessary technical knowledge to act as agents for manufacturers of plant and machinery. The Group estimate that some two-thirds of total British exports are handled by merchants, and the short-comings mentioned above must therefore apply to some of them. There are obvious difficulties involved in having second or third-hand contact with customers, of which most engineering companies are keenly aware. At the same time, there is a case for trading through an established export merchant house rather than overseas agents, who are not easy to supervise and with whom it is difficult to maintain close contact. The Group's headquarters are in the London Chamber of Commerce building in Cannon Street, E.C.4. The chairman, Mr. Robert Brodie, is London manager of James Finlay and Company, Limited.

* * *

NATIONAL INDUSTRIAL FUEL EFFICIENCY SERVICE

As recently announced in the House of Commons, responsibility for the fuel efficiency service to industry was transferred to the new National Industrial Fuel Efficiency Service from the Ministry of Fuel and Power on May 1. Sir Leslie Hollinghurst, chairman of the Board of the new Service, has stated that the majority of the engineering staff of the Ministry's Fuel Efficiency Branch have been seconded to form the nucleus of the new organisation, which will collaborate with other existing organisations that are aiming at improving the efficiency with which fuel is used in industry.

Among the ideas under consideration is that firms might wish to register with N.I.F.E.S. for a regular service. This might entitle them to visits from a skilled stoker-demonstrator to help their boiler-house staff in difficulties, to the advice of an engineer on general problems of fuel utilisation, or to detailed surveys of those parts of the works where the greatest savings seeemed likely. Another possibility, which might appeal to firms who are conscious that their use of fuel and steam needs overhauling but which cannot spare their own hard-pressed engineers to specialise, is to hire for a few months the services of a N.I.F.E.S. engineer.

The Ministry is handing over to N.I.F.E.S. the mobile testing units which have been used to measure the consumption of steam throughout a factory and to trace losses to their sources. Heat and power surveys will be made available to industry at the same charge as the Ministry has made. General advice on fuel efficiency has been provided by the Ministry free, and here again N.I.F.E.S. will be making no immediate change. However, a considerable development in the scale of operations will only be possible if N.I.F.E.S. is able to earn revenue to supplement the financial support it is receiving from the fuel industries.

All work carried out by N.I.F.E.S. will be on a confidential basis, and publication of the results, either in whole or in part, will not be considered without the approval of the firm concerned. At the same time, it is hoped that firms would generally consent to make known the savings in fuel that had been achieved.

The head offices of the Service have been opened at 71 Grosvenor-street, London, W.1. The Scottish office is at 145 St. Vincent-street, Glasgow, C.2. In the course of the next few months, N.I.F.E.S. expects to open district offices in Leeds, Manchester, Birmingham, Cardiff and Bristol, with sub-offices elsewhere. Meantime, the work will continue from the Ministry of Fuel and Power's regional offices in those cities, and also in Newcastle, Nottingham, Cambridge, Reading and Tunbridge Wells.

* * *

Letters to the Editor

NAPIER "NOMAD" ENGINE

Sir, I found your article in ENGINEERING of April 30 (page 571), on the design of the "Nomad" turbo-Diesel aero-engine very interesting, but on comparing Fig. 9 with the sketch of the gearing in Fig. 4, it seemed to me that the arrangement of the epicyclic gear had been wrongly portrayed.

The sketch (Fig. 4) shows the planet carrier as being directly geared to the main shaft of the speed-varying device, which would surely mean that about 70 per cent. of the total turbine surplus power would be transmitted through the discs, instead of 30 per cent. as stated in the article.

Yours faithfully,
NORMAN ROBERTSON.
(Second-year engineering student, Glasgow University.)

73 Edrom-street,
Glasgow, E.2.
May 1, 1954.

[We have received the following reply from D. Napier and Son, Limited, to Mr. Robertson's letter:

"Your correspondent, Mr. Robertson, is quite right in saying that Fig. 4 is in conflict with Fig. 9. The latter, i.e., the sectioned view of the reduction gearing, including variable-speed gear, is correct. Fig. 4 is based on an early diagram of the engine in which the variable-speed gear was coupled into the epicyclic gear in the manner shown, and unfortunately this diagram has never been brought up to date. It was never intended that it should be used for tracing out the intricacies of the variable-speed gear mechanism! In the early scheme, depicted in Fig. 4, the overall gear ratio was higher than that employed at present, and this resulted in the epicyclic gear being run at somewhat different speeds from the present arrangement. The net result was that, although the variable-speed gear did transmit a higher percentage of the turbine surplus power than 30 per cent., it was only about 40 to 45 per cent., and not 70 per cent. as suggested by Mr. Robertson. In conclusion, we would like to congratulate Mr. Robertson on his perspicacity in drawing our attention to this error."—Ed., E.]

DRAWINGS IN "ENGINEERING"

Legibility of Back-Lining

Sir, Now that the changes in the presentation of your journal have become familiar, it is possible to appreciate how great an improvement they represent in certain respects. There is, however, one more change that I should like to see introduced.

I have recently had occasion to compare the illustrations which you published with the similar illustrations published in the house journal of a famous firm. Both sets of illustrations had clearly been prepared from the same working drawings, but yours were far less readily legible to an eye used to drawing-office practice. Inspection showed that in your illustrations, lines had been thickened up according to some system which is presumably conventional, whereas in the house journal the blocks had clearly been prepared directly from the working drawings, and thus all lines were of their "proper" thickness.

It would be interesting to hear not only editorial opinion but also the opinions of your readers, as to which convention is preferable.

Yours truly,
D. B. WELBOURN.

Engineering Laboratory,
University of Cambridge,
Trumpington-street,
Cambridge.
May 5, 1954.

["Back-lining" of engineering drawings is an ancient and honoured convention – it was used, for example, in the first issue of ENGINEERING in 1866 – and is intended to make drawings more, not less, legible. It has gone out of fashion in normal drawing-office work, like so many drawing practices, because it costs time and money. We continue it in our editorial pages (several examples will be found in this issue) because we believe the expense is worthwhile in cases where the drawings will be examined by thousands of readers.

The back-lining convention is that light falls on the object from the top left-hand corner at an angle of 45 deg. Those edges on which the light falls are indicated by thin lines, and those which would give rise to a shadow are shown by thick lines. Thus a projecting member is readily distinguished from a hole. Mr. Welbourn's letter is the first suggestion we have had that back-lining is not fully appreciated. Perhaps the simplification of drawing-office practice in recent years has resulted in other engineers viewing back-lining in the same way. We would be glad to receive further comments.—Ed., E.]

* * *

NATIONAL SOCIETY OF MASTER PATTERNMAKERS

First Meeting in London

We gave on page 549 of our issue of April 30 some particulars regarding the foundation of the National Society of Master Patternmakers. The first London meeting of the Society was held at the Waldorf Hotel, Aldwych, on May 5, and the President, Mr. B. Levy, occupied the chair. In a brief speech he gave, in outline, the main objects of the Society, which are to foster friendship and co-operation among its members; to promote, encourage, support and protect the status and general interests of master patternmakers; to develop scientific and economical methods of production, distribution, and application of pattern equipment; to establish standards and gradings for pattern equipment; to enter into arrangement for reciprocal concessions and co-operation to benefit the members of the Society; to aid in the improvement and elevation of the knowledge of members; to collect and distribute useful information; to eliminate unfair practices; to establish standard forms of guarantee; to nominate representative members of the industry; and to make arrangement for the expansion of the export trade of the pattern industry.

Mr. Levy added that four general meetings would normally be held annually, in September, December, March and May, and the next meeting would be held in Manchester in September.

Following the business meeting, at which a final contingent of founder members were enrolled, a silent film showing the making of moulds and castings for propellers for the S.S. Queen Elizabeth and other large vessels was exhibited. A commentary on the film was given by Mr. J. M. Langham, of Messrs. J. Stone and Company (Charlton), Limited.

The secretaries of the Society are Messrs. Mann, Judd and Company, 8 Frederick's-place, Old Jewry, London, E.C.2.

HEAVY-WATER ATOMIC REACTOR

Construction Started at Harwell

Construction of a heavy-water atomic reactor at Harwell was begun when Sir John Cockroft, director of the Atomic Energy Research Establishment, cut the first sod on the new site. This is the fourth pile to be built at the establishment and will be the first in the United Kingdom to use heavy water as the moderator.

For the last six years Harwell has had available two piles, BEPO and GLEEP. They have been used for research in a very wide range of subjects. In particular they have been used for work carried out in connection with the design of the plutonium-producing piles now in operation at Windscale and the newer nuclear-energy electricity generating station now under construction at Calder Hall. However, the more advanced types of power pile to which Harwell is now giving detailed consideration are likely to operate at a much higher intensity than has been the case previously, and this should lead eventually to a reduction of capital costs and lower overall costs of reactor operation.

Accordingly, it has been decided to build at Harwell, in addition to the zero-energy fast-fission reactor (which has now been operating for some two months) a small research reactor operating at a very high intensity to permit the necessary experimental studies to be carried out. Besides fulfilling this function the new pile will make it possible to produce certain radio-active isotopes such as cobalt 60 which cannot be made with sufficient specific activity in BEPO. Until now BEPO and the Windscale piles have been the main source of radio-active isotopes.

The use of heavy water as a moderator enables the required facilities to be obtained at a lower capital cost than would be possible with a graphite-moderated system. The reactor will use as fuel highly enriched uranium which will be supplied from the diffusion plant at Capenhurst.

General design of the new pile is being undertaken by the Atomic Energy Research Establishment, while detailed design and provision of reactor components will be a responsibility of Head Wrightson Processes, Limited, 24 Baltic-street, London, E.C.2. The Ministry of Works are undertaking the general site work.

* * *

MECHANISED FARMING

Opening of Training Centre

A mechanised-farming centre, established at Boreham, Essex, by the Ford Motor Company, Limited, Dagenham, was opened on May 4, by Major General Sir Harold Wernher, G.C.V.O. chairman of the National Institute of Agricultural Engineering. This training school has been founded to encourage the better usage of modern farm equipment.

The courses arranged are divided into two categories, the first is intended for dealers and sales staffs both from the British Isles and from overseas, and the second for tractor owners. Those eligible for the second series of courses include overseas government officers, N.A.A.S. machinery advisers, F.A.O., Unesco and I.L.O. representatives, and members of farming clubs, agricultural colleges and trade delegations. In general the courses are of five days duration.

The principal of the school is Mr. E. B. Black, B.Sc., A.M.I.Mech.E., and the director of studies is Mr. E. J. Bullock, Dip. Agric. (Wye).

In a speech given on the occasion of the opening, Sir Patrick Hennessy, deputy chairman and managing director of the Ford Motor Company, reported that Britain had, in proportion to acreage, the largest number of mechanised farms in the world and the greatest agricultural output per man. Everybody everywhere, was interested in agriculture, he said, and his company was exporting tractors to many parts of the world, including America where they competed successfully with American-built machines.

ROLLS AND ROYCE

A HISTORIC MEETING

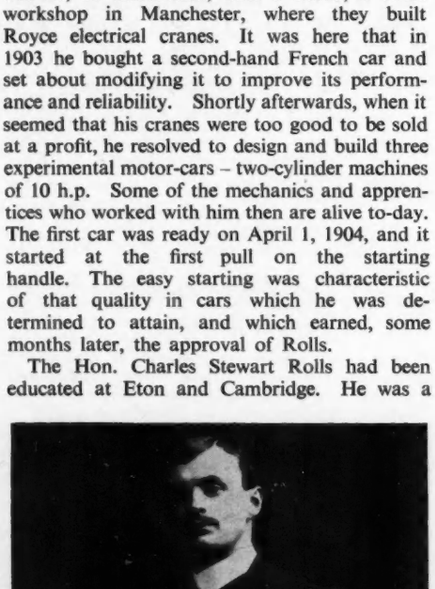
The 50th anniversary of the meeting of Rolls and Royce has a special significance for engineers. They can share with the general public that sense of admiration, even awe, which the name Rolls-Royce inspires. But beyond that each is reminded, according to his age and experience, of the ideal in engineering which it was once his aim to achieve, or of the ideal which now, as a young man, he confidently believes he can achieve. For the hard truth is that in the industrial world, perfection of product is seldom the test of success or efficiency.

Royce was the exception who proved the rule. It was because others compromised on quality – for perfectly sound business reasons which satisfied the majority of customers – that he was able to maintain his high standards, demanding the finest work from his colleagues and employees, and giving, to a fortunate few, the " best car in the world."

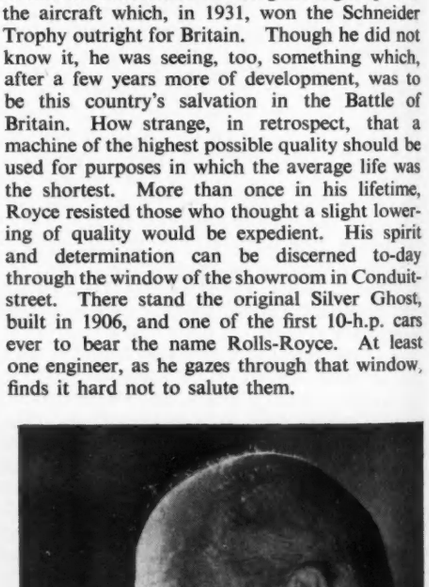
Frederick Henry Royce spent his early years in difficult circumstances. His father was a miller who died when Henry was nine. But after a period as a messenger boy he had the good fortune to spend a holiday with an aunt who arranged for him to enter the Great Northern Railways works at Peterborough as an apprentice. He was only able to spend three years there, but he subsequently worked for a firm of toolmakers and for two electrical firms. In 1884, when he was 21, he established, with a friend, a small workshop in Manchester, where they built Royce electrical cranes. It was here that in 1903 he bought a second-hand French car and set about modifying it to improve its performance and reliability. Shortly afterwards, when it seemed that his cranes were too good to be sold at a profit, he resolved to design and build three experimental motor-cars – two-cylinder machines of 10 h.p. Some of the mechanics and apprentices who worked with him then are alive to-day. The first car was ready on April 1, 1904, and it started at the first pull on the starting handle. The easy starting was characteristic of that quality in cars which he was determined to attain, and which earned, some months later, the approval of Rolls.

The Hon. Charles Stewart Rolls had been educated at Eton and Cambridge. He was a pioneer motorist with the means and the zest to enjoy the hazards and sport of motor racing in the 'Nineties. When he met Royce he was a prosperous dealer in Continental motor-cars, with offices in Conduit-street, London. The two men were introduced to each other at the Midland Hotel in Manchester, by Henry Edmunds, who had bought one of Royce's first three cars. A drive in a Royce car was enough to convince Rolls that here was a British car which was fine enough for him to sell. He undertook to sell all the cars Royce could build, and the subsequent award of a diploma and gold medal at the Paris Salon confirmed him in his judgment.

The famous name was born on December 23, 1904, in a working agreement between C. S. Rolls, Limited, and Henry Royce, Limited. The growth of the firm and the personalities who have taken part have been admirably described by Mr. Harold Nockolds in his book *The Magic of a Name*. Reading that book now, it seems hardly credible that so much engineering history should have been made in 50 years. Apart from the cars, the development of aero-engines (piston and gas-turbine), armoured cars and tanks, the R.R. alloys, and, more recently, the Rolls-Royce oil engines, have conformed to the same unwavering standards that Royce set for himself from the start. Before he died in 1933, he had the satisfaction of seeing his engine power the aircraft which, in 1931, won the Schneider Trophy outright for Britain. Though he did not know it, he was seeing, too, something which, after a few years more of development, was to be this country's salvation in the Battle of Britain. How strange, in retrospect, that a machine of the highest possible quality should be used for purposes in which the average life was the shortest. More than once in his lifetime, Royce resisted those who thought a slight lowering of quality would be expedient. His spirit and determination can be discerned to-day through the window of the showroom in Conduit-street. There stand the original Silver Ghost, built in 1906, and one of the first 10-h.p. cars ever to bear the name Rolls-Royce. At least one engineer, as he gazes through that window, finds it hard not to salute them.



The Hon. Charles Stewart Rolls



Sir Henry Frederick Royce, Bart.

PERSONAL

SIR HENRY WILSON SMITH, K.C.B., K.B.E., has been appointed deputy chairman of Powell Duffryn Ltd., 19 Berkeley-street, London, W.1.

MR. A. B. WARING has been elected President of the Society of Motor Manufacturers and Traders, 148 Piccadilly, London, W.1, in succession to MR. W. R. BLACK, who now becomes deputy President. The two vice-presidents are MR. R. F. HANKS, M.I.Mech.E., who succeeds Mr. Waring, and DR. F. LLEWELLYN SMITH, M.Sc., M.I.Mech.E., who is continuing in that office for a third year. MAJOR-GENERAL J. S. CRAWFORD, C.B., C.B.E., M.I.Mech.E., M.I.Mar.E., has been re-elected for a further term as treasurer of the Society.

MR. G. P. CLAY, M.A., M.I.Mech.E., chief engineer, Metals Division, Imperial Chemical Industries Ltd., has been elected to the board of that Division.

BRIGADIER R. S. G. STOKES, C.B.E., D.S.O., M.C., is to be inducted as President of the Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2, on May 27.

MR. A. C. WADDY, O.B.E., has been elected chairman of the Dry Dock Owners and Repairers Central Council for 1954-55. ENGR. CAPTAIN G. VILLAR, C.B.E., R.N., has been elected senior vice-chairman and MR. P. GIFFORD junior vice-chairman.

DR. B. F. J. SCHONLAND, C.B.E., M.A., F.R.S., who is at present head of the Bernard Price Institute of Geophysical Research, University of Witwatersrand, South Africa, is to be appointed deputy director, Atomic Energy Research Establishment, Harwell, as from a date towards the end of 1954.

MR. A. H. GARNETT, principal surveyor for Australia, is to retire from service with Lloyd's Register of Shipping on June 30, having reached pensionable age. His successor is MR. B. P. FIELDEN.

MR. C. GILLAM is to hold the new appointment of chief engineer to the Communications Division of Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex. He will be working in close conjunction with MR. A. W. COLE, manager of the Division.

MR. GEORGE BOEX is retiring under the age limit from the joint managing directorship of the British Aluminium Co. Ltd., Norfolk House, St. James's-square, London, S.W.1, on July 4, and will be succeeded by MR. W. J. THOMAS. Mr. Boex will remain a director.

MR. D. A. THOMSON, B.Sc., has been appointed to the board of the Belmos Co. Ltd., Bellshill, Lanarkshire.

MR. E. F. HUCKVALE, for over 25 years secretary of Jaguar Cars Ltd., Coventry, has been elected to the board.

MR. R. J. BARCLAY, managing director of Markham & Co. Ltd., has been elected a director of John Brown & Co. Ltd.

MR. A. E. NEATE, lately director-general of machine tools, Ministry of Supply, has been elected a director of Wickman Ltd.

Dowty Equipment Ltd., Arle-court, Cheltenham, have announced the appointment of MR. E. J. NICHOLL, B.Sc. (Eng.), to the board of Dowty Equipment of Canada Ltd. MR. T. A. WHITBY, secretary and commercial manager, Coventry Precision Ltd., has been elected to the board of that company.

MR. F. N. LLOYD has been elected chairman of the British Steel Founders' Association in succession to MR. T. H. SUMMERSON.

MR. H. C. VAN de VELDE has been elected President of the Comité International Radio-Maritime (C.I.R.M.) for the eighth year in succession.

MR. B. THORNTON has relinquished his directorship of the Wellman Smith Owen Engineering Coporation Ltd., Parnell House, Wilton-road, London, S.W.1, for reasons of ill health.

MR. A. S. MANSELL, sales manager, R. and A. G. Crossland Ltd., Walsall, Staffordshire, has been elected a director of the company.

Rhodes, Brydon and Youatt Ltd., Waterloo Engineering Works, Gorsey Mount-street, Stockport, announce that MR. J. RICHMOND has been appointed their London manager, that MR. C. W. HAYDON has been appointed technical representative in London, and that MR. M. J. B. HODGSON continues to represent their interests in the industrial market.

MR. JOHN CREEK has been made sales director of Fibreglass Ltd., Ravenhead, St. Helens, Lancashire.

MR. G. C. BATEMAN has been appointed by Wickman Ltd., Coventry, to be direct factory representative for Lidkopings Mekaniska Verkstads A/B, Lidkoping, Sweden, and Ulvsunda Verkstader A/B, Ulvsunda, Stockholm, in the United Kingdom and other countries.

BUSINESS CHANGES

BROOK MOTORS LTD., Empress Works, Huddersfield, have moved their Glasgow sales office to Carlton House, Blythswood-square, Glasgow, C.2 (Telephone: Central 1045).

THE DUNLOP RUBBER CO. LTD., have acquired the entire share capital of Brynmawr Rubber Ltd., Brynmawr, Wales, from ENFIELD CABLES LTD.

W. CANNING & CO. LTD., Great Hampton-street, Birmingham, 18, are moving their Sheffield premises on June 1 to 1 South Parade, Shalesmoor, Sheffield, 3 (Telephone (unchanged): Sheffield 24101).

The name of GOODENOUGH CONTRACTORS' MACHINERY LTD., 70-72 London-road, Twickenham, Middlesex, has been changed to GOODENOUGH PUMPS LTD.

The firm of HIGH PRESSURE COMPONENTS LTD., has been bought out by MR. H. W. BOWEN, O.B.E., a former managing director of E.M.I. Factories Ltd. He is the chairman of the new company and has been joined as a co-director by SIR WOLSTAN DIXIE, Bt. Large-scale expansion is planned.

The aviation work formerly carried out by the BRISTOL AEROPLANE CO. (WESTON) LTD., has been brought under the direct control of the aircraft division of the parent company, THE BRISTOL AEROPLANE CO LTD., Filton House, Bristol. Building activities in future will be the responsibility of a new division to be known as the buildings division. MR. W. STRACHAN remains in charge of the WESTON factory. MR. P. W. LAWSON has been appointed general manager of the buildings division and MR. A. D. CAWSE, divisional secretary.

THE INSTITUTION OF PRODUCTION ENGINEERS have removed their offices to 10 Chesterfield-street, London, W.1. (Telephone: GROsvenor 5254/9.)

PERCIVAL AIRCRAFT LTD. have changed their name to HUNTING PERCIVAL AIRCRAFT LTD., Luton Airport, Bedfordshire.

EWBANK AND PARTNERS LTD. are setting up in Canada an associated company, EWBANK AND PARTNERS (CANADA) LTD., Toronto. The new company will be under the general direction of MR. J. T. MOORE, a director of the parent company. The Canadian company will operate in close association with CRIPPEN WRIGHT ENGINEERING, LTD., Vancouver.

J. STONE AND CO. LTD., Deptford and Charlton, have bought the engineering interests of CHANCE BROTHERS LTD., Smethwick. A new company, STONE-CHANCE LTD., will be formed with MR. BRYAN PRESTON, deputy chairman of J. Stone (Holdings) Ltd. as chairman, and MR. JOHN RAYMOND, up till now managing director of Chance Brothers, as managing director. Chance Brothers Ltd. will continue to manufacture their glass products, with DR. W. M. HAMPTON, formerly technical director, as managing director and MR. C. J. S. NEWMAN as deputy.

EDWARD WILCOX & CO. LTD., Manchester, are opening a new London office at Fulwood House, Fulwood-place, Holborn, London, W.C.1. (Telephone: CHAncery 2206.)

A. REYROLLE & CO. LTD., Hebburn, Co. Durham, have moved their North Midland and Leeds area office from Park-row to 20-22 St. Paul's-street, Leeds, 1. The manager is MR. A. J. COVENEY, M.I.E.E., and the telephone remains unaltered as Leeds 21521.

A new company, ARDLEIGH ENGINEERING LTD., of Langham-lane, Langham, Colchester, Essex, has been formed to provide engine-speed governors and other control equipment for engine builders.

The London office of the PARSONS ENGINEERING CO. LTD. has been moved from Duke's-court, St. James's, to 9-10 Cavendish-square, London, W.1 (Telephone: LANgham 8351-2-3). The registered offices and London sales office of ASSOCIATED BRITISH ENGINEERING LTD. are now also at this address.

BURTON, GRIFFITHS & CO. LTD., Kitts Green, Birmingham, 33, have been appointed sole selling agents in Great Britain and Northern Ireland for the sale of "Sparcatron" equipment. This technique of machining hard metals by electric spark discharge was described and illustrated on page 121 of our volume 174 (1952).

Obituary

COLONEL H. J. WELLINGHAM, M.C., T.D.

We regret to record the death of Colonel H. J. Wellingham, M.C., T.D., which occurred, at the age of 59, on Wednesday, May 5.

Herbert John Wellingham was born at Swaffham, Norfolk, on July 16, 1894. He was educated at Hunstanton and Woodbridge schools and at the age of 16 he became a pupil with Davey, Paxman and Company, Limited, Colchester, simultaneously attending classes at the local technical college. He served in the Royal Field Artillery during the 1914-18 war, attaining the rank of captain and being awarded the Military Cross for his services.

Early in 1919 he rejoined Davey, Paxman and Company and for the next two years acted as one of their mechanical engineers in London. Subsequently, he held a similar appointment with A.G.E. Limited and from July, 1922, to 1923 was inspecting automobile engineer for the United Motor and General Insurance Company, Limited, London. He was then engaged as mechanical engineer in the London office of the Sullivan Machinery Company, Inc., an American firm making pneumatic tools and mining and quarrying equipment, until in January, 1925, he joined the Western Telegraph Company, Limited, and was placed in charge of their mechanical and electrical training workshops in Madeira.

At the end of that year he took over similar duties in the workshops of the Eastern Telegraph Company in London and six years later was appointed assistant general manager (engineering) in the United Kingdom to Cable and Wireless, Limited. In this position he was responsible for the maintenance and repair of all the concern's plant and transport in this country.

In September, 1939, he was recalled to the Army and in 1942 became Deputy Assistant Director Ordnance Services in the Northern Command.

He returned to Cable and Wireless, Limited, as telegraph manager, Post Office cable and wireless services, and held this post until his death. Colonel Wellingham was elected an associate member of the Institution of Mechanical Engineers in 1920 and was transferred to the class of member in 1942. He joined the Institution of Electrical Engineers as a graduate in 1928, becoming an associate in 1930 and an associate member in 1948.

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We regret also to record the deaths of the following :

MR. PHILIP TREHEARNE WARD, in a hospital in Sheffield, on April 29, after a long illness, at the age of 35. He was a director of Thos. W. Ward, Ltd., Albion Works, Sheffield, and the son of Mr. Ashley S. Ward, who is President of the company and a former Master Cutler of Sheffield. Mr. P. T. Ward was educated at Charterhouse and served in Fighter Command, R.A.F., in the late war. He entered Thos. W. Ward in 1937 and was elected a full director in 1948.

MR. CHARLES MACFARLANE, at the age of 87. He retired 16 years ago from the position of works manager to George Clark (1938), Limited, Sunderland. Mr. MacFarlane joined the firm when he was 14 as an apprentice, became a foreman in 1889 and works manager in 1906.

MR. ALBERT EDWARD LEEK, on May 4, at the age of 72. Until his retirement six year ago, Mr. Leek was general manager of the Distington Engineering Co., Ltd.

AWARDS BY THE ROYAL AERONAUTICAL SOCIETY

The Royal Aeronautical Society announce that the following awards were presented to the recipients by Sir William Farren, the retiring President, at the Annual General Meeting of the Society on May 6.

The R. P. Alston Memorial Prize to Mr. M. L. Burgan, for his contributions to the flight testing of blind landing equipment; the Edward Busk Memorial Prize to Mr. D. Kuchemann for his two papers: (i) "Types of Flow on Swept Wings" and (ii) "The Distribution of Lift Over the Surface of Swept Wings"; the Usborne Memorial Prize to Mr. A. J. Barrett, for his paper on "Unsymmetrical Bending and Bending Combined with Axial Loading of a Beam of Rectangular Cross Section into the Plastic Range"; the Pilcher Memorial Prize to Mr. J. D. Sibley, for his paper on "An Introduction to the Helicopter"; the Orville Wright Prize to Mr. Alan Powell, for his paper "On the Noise Emanating from a Two-Dimensional Jet above the Critical Pressure," jointly with Mr. G. E. Gadd for his paper on "Some Aspects of Laminar Boundary Layer Separation in Compressible Flow with no Heat Transfer to the Wall"; the Branch Prize to Mr. J. Taylor, for his paper on "Structure Weight"; the E. J. N. Archbold Memorial Prize, awarded annually to the student obtaining the highest marks in the City and Guilds examination (Aeronautical Engineering Division), to Mr. Jeffrey Thwaite; the Baden-Powell Memorial Prize, awarded to the best student in Part II of each Associate Fellowship examination of the Society, to Mr. W. B. Blydenstein.

The following medals have been awarded and will be presented to the recipients by Sir Sydney Camm, the President, at the Royal Institution on May 20, 1954, preceding the Wilbur Wright Memorial Lecture, which is to be given by Dr. A. E. Russell, on "The Choice of Power Units for Civil Aeroplanes":

Honorary Fellowship Diplomas to Sir A. H. Roy Fedden and Sir Frank Whittle; the Society's Gold Medal to Sir Geoffrey Taylor, for outstanding contributions to aeronautical science; the Society's Silver Medal to Professor W. J. Duncan, for outstanding work in aeronautical science and education; the Society's Bronze Medal to Mr. H. B. Howard, for his long and valuable work on aircraft structures; the British Gold Medal to Mr. A. G. Elliott for outstanding practical achievement in the design and development of aircraft engines; the British Silver Medal to Mr. R. Brie, for practical contributions to the development of rotary wing aircraft; the George Taylor (of Australia) Gold Medal to Mr. V. A. M. Hunt, for his paper on "Air Traffic Control To-day and Tomorrow"; and the Simms Gold Medal to Mr. E. D. Keen, for his paper on "Integral Construction – Its Application to Aircraft Design and its Effect on Production Methods."

* * *

CONTRACTS

Diesel-Electric Locomotives. A contract valued at £4¾ millions for the supply of Diesel-electric locomotives to Coras Iompair Eireann (Irish State Transport) has been awarded to Metropolitan-Vickers Electric Co. Ltd., Trafford Park, Manchester, 17. Ninety-four locomotives are to be supplied, 60 of the 1,200-h.p. six-axle type and 34 of the 550-h.p. four-axle type. The electrical equipments will be manufactured by Metropolitan-Vickers at Manchester and Sheffield, the Diesel engines by CROSSLEY BROTHERS LTD., Manchester, and the mechanical parts by METROPOLITAN-CAMMELL CARRIAGE AND WAGON CO. LTD., Birmingham.

Goods Lifts. In May, 1953, THE EXPRESS LIFT CO. LTD., received an order for four 3-ton single-speed goods lifts for the Takoradi Harbour scheme, Gold Coast. These lifts have been completed and shipped from Liverpool. A further order has now been received by the company for another five heavy goods lifts; these lifts are each to carry 5 tons and incorporate automatic levelling equipment.

GROUPS WITHIN INDUSTRY

CONTENDING FORCES RESOLVED BY EDUCATION

To distinguish between those of our actions which stem from personal idiosyncracy and those which are the result of group constraints is often a difficult matter; this was acknowledged by Mr. H. N. C. Stevenson, O.B.E., in a lecture entitled "The Importance of Custom in Industrial Society," held on Tuesday, April 13. The lecture, which was one of a series of six on "Man in Britain," arranged by the Royal Anthropological Institute, 21 Bedford-square, London, W.C.1, was devoted to a discussion of the forces exerted upon an individual by the different groups to which he belonged and dealt particularly with the inter-play of these forces in industrial society.

Mr. Stevenson believed that a greater proportion of our behaviour than we realised was governed by the traditions and customs of the groups which held our allegiance. Such groups might be national or local communities, religious bodies, clubs, unions, professions, or one of many other forms of association. The extent to which a group could influence us, whether membership of it were fortuitous, or chosen on grounds of common interest, was related to its power to protect us – or to withhold protection – for groups were almost always protective organisations.

Among the most important groups were those which protect or provide our livelihood. In an industrial society the two principal bodies of this kind were the firm or company which employed us and the trade union which, according to our craft or calling, undertook to defend our interests. The aims of these groups were seldom identical and often incompatible; but it was fundamental to the democratic pattern of life that the power of one authority should at least be partly balanced by that of another.

THE SHIFT OF AUTHORITY

It had been observed that there exists at present a tendency for influence and authority to shift increasingly into new channels. Where groups had once been primarily local bodies with chains of command linked by a vertical hierarchy, power was passing into nation-wide groupings, spread, as it were, in horizontal layers. The vertical groups included such organisations as independent industrial companies and military units, and the horizontal layers represented, for example, trades unions and employers' associations.

This drift of prerogative from vertical into horizontal channels could be explained largely in terms of the hold each group had over its members and in particular by the comparative consequences of expulsion from different groups. If a member of a cricket club or an engineering company were dismissed for some misdemeanour, he might play cricket elsewhere or seek employment with another firm. If, however, a doctor were struck from the medical register or a craftsman were expelled from his union, both would lose their means of livelihood. Not only would the doctor be unable to practice his profession and the craftsman his trade, but the arduous and costly years of study or apprenticeship would have been spent in vain.

Hence the authority of a union over its members was likely to be greater than that of a firm over its employees. This explained perhaps the rejection of merit money or piece rates by many workpeople; the group in this case was strong enough to override the individual's desire for immediate personal gain.

THE AIM OF INDUSTRY

Industry was primarily concerned with producing goods and, although fair returns for labour and invested capital, equity and the welfare of the employee were essential to its proper conduct, they were not its central aim. Since, at the present time, the whole nation's prosperity depended on the production of goods abundantly and cheaply, it was imperative that industry should be in a position to fulfil this purpose. The conditions of industrial organisation must therefore be such that reasonable measures calculated to raise production could be introduced unhindered. If this was to come about, the horizontal and vertical groups must be made increasingly aware of the very considerable areas over which their interests coincided and prejudice and uninformed suspicion must be eliminated.

The balance between the contending groups in industry could therefore, it was believed, be restored by means of suitable instruction. At present, companies had their training schemes and unions their lecture courses, but, although both served valuable purposes, in neither could industry be shown from the broadest point of view.

PROBLEM RESOLVED BY EDUCATION

Since industry was so fundamental a feature of our society, it would be reasonable to suppose that some of its aspects might profitably be represented in the curricula of schools. Many pupils left school to enter a factory and found it difficult to form a picture of the industrial complex which lay outside their immediate duties and surroundings. Instruction in industrial organisation, practices and aims would not only prepare young people for factory life but also leave them less exposed to the influence of the misguided.

Thus the stresses which existed between the vertical and horizontal groupings in industrial society might be resolved. Their rival aims would then be united in the single purpose of producing the greatest volume of goods consistent with the well-being of the producer.

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TRADE WITH SWEDEN

Formation of British-Swedish Chamber of Commerce

To further British trade interests in that country, the British-Swedish Chamber of Commerce in Sweden has been formed, with headquarters in Stockholm, and was formally inaugurated at a meeting there on April 29.

The first steps towards its establishment were taken by local British and Swedish businessmen more than a year ago, and, in addition to them, over 250 firms in the United Kingdom have expressed their willingness to become members. The project has the full approval of the Board of Trade and the Federation of British Industries.

Mr. R. Hunt Taylor, head of the European department of the Federation of British Industries, is acting as honorary secretary to a small sponsoring committee in London and all inquiries about the chamber should be addressed to him at 41 Buckingham Palace-road, London, S.W.1, for the time being. Mr. A. E. Wernly, at present managing director of Thomas W. Ward (Scandinavia) AB, has been appointed secretary to the chamber and will take up his new duties in Stockholm in June.

THE JUNIOR INSTITUTION OF ENGINEERS

70th Anniversary of Foundation

A dinner to celebrate the seventieth anniversary of the foundation of the Junior Institution of Engineers was held in the Connaught Rooms on Friday, April 30. The chairman on this occasion was Air Commodore F. R. Banks, C.B., O.B.E., the immediate past President of the Institution, as the President, Sir John Hacking, M.I.E.E., was unable to be present.

The toast of "The Institution" was proposed by Mr. David M. Watson, B.Sc., M.I.C.E., vice-President of the Institution of Civil Engineers, who referred to the founding of the Junior Institution in 1884 and to its aims. It had, he said, been founded "by juniors for juniors" and, although many of its present members were veterans of the engineering profession, it still placed the highest value on the capacity of younger men to introduce and accept new ideas; this quality formed an admirable combination with the mature judgment of older and more experienced men. Mr. Watson also congratulated the Institution on its recent acquisition of a home of its own.

Mr. S. G. Clark, Chairman of the Institution, replied.

ELECTRICITY AND THE FUTURE

Mr. T. Graeme N. Haldane, M.I.C.E., M.I.E.E., Fel.A.I.E.E., who proposed the toast to "Electricity and the Future," stated that, during the last half-century, the consumption of electricity had doubled in each decade and that, relatively to other commodities, its price had fallen. He believed that consumption would continue to increase. Whatever the primary source of power, whether coal, water, or atomic energy, it would always be converted to profitable use through the medium of electricity.

In his response, Mr. Ernest A. Mills, M.I.E.E., M.I.Mech.E., M.I.C.E., formerly Deputy Chairman of the London Electricity Board, reported that every effort to increase the thermal efficiency of power production was being made. A limiting factor was the availability of cooling water; but new heat cycles were continually being investigated with the object of increasing the capacity of existing plant.

The problem of rationalising urban electricity supplies was also an urgent one, and as formidable, he said, as that of rural electrification. In certain places there were six different supply systems in the same street. It would require more than ten years and an expenditure of fifty-million pounds to standardise London's electricity system alone. The cost would fall on the consumer but, unless the changes were made, such anomalies as independent direct-current supply systems would continue to exist. Coal supplies were a further difficulty and could not continue indefinitely; nuclear energy would soon be available, however, and two 20-MW sets were already under construction.

In responding to the toast, "Our Guests," proposed by Mr. A. S. Ladley, M.Inst.Met., vice-chairman of the Institution, Mr. Harold Bishop, C.B.E., B.Sc. (Eng.), F.C.G.I., M.I.E.E., M.I.Mech.E., F.I.R.E., President of the Institution of Electrical Engineers, declared that engineers were bad publicists. It was imperative, he said, that the public should be informed of the engineer's purpose and of his place in society.

Mr. J. H. Sharpe, vice-chairman of the Institution, proposed the toast to "The Chairman" and, in his reply, Air Commodore Banks emphasised the importance of selling our products abroad.

MARINE RADAR EQUIPMENT

Motor Vessel Equipped for Demonstration

The Motor-Vessel Navigator, which has been fitted out by Decca Radar, Limited, 1-3 Brixton-road, London, S.W.9, with a full range of marine radar equipment, including one of their Navigator sets, left London on Wednesday, May 9, for a three months' cruise to North European ports. Bremen will be the first port of call, as a maritime congress is now being held there. Other German ports will be visited, and the vessel will then call at the principal ports in Denmark and Sweden, the Dutch ports being visited on the return journey which will be concluded towards the end of July.

The object of the cruise is to give shipowners and others interested an opportunity of seeing Decca apparatus in actual use under practical working conditions. We illustrated and described the principle of the Navigator system in our 167th volume, on page 439 (1949). A Mark V set is installed, which is capable of receiving nine Navigator chains operating on different frequencies. Three types of cathode-ray tube display units, for use with radar pulses transmitted from a rotating scanner on the vessel, are installed for demonstration purposes. The latest of these is known as Type 45 and has a 12-in. screen. In this class of equipment both the magnetron and the initial circuits of the receiver are mounted close to the scanner, thus reducing the length of the wave guides to the minimum possible. The connections to the output stage of the receiver are made at an intermediate frequency, so that simple conductors can be employed.

In this set pulse lengths of both 0·1 second and 1·0 second are employed, the former to give high definition at short ranges and the latter for detection at long ranges. It is claimed that this feature ensures an outstanding performance at a maximum range of 45 miles and also gives exceptionally high discrimination and definition at the shortest range of half a mile. Other notable features included are a differentiation circuit, which enables targets to be seen clearly in heavy rain or snow and a stand-by switch which materially increases the life of the magnetron and the cathode-ray tube.

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MATERIALS HANDLING DEMONSTRATION

Military Requirements

An interesting and well-staged demonstration of improved methods of handling stores with the aid of fork-lift trucks was held by the Institute of Materials Handling, in collaboration with the War Office, in the Central Ordnance Depot, Didcot, Berkshire, on Thursday, April 29. Fork-lift and pallet trucks were shown shifting stacked pallets containing stores, loading and unloading standard open and closed railway wagons, and loading a road vehicle from both ground and platform levels. The demonstrations were accompanied by running commentaries explaining both the operations and techniques involved.

Senior army officers were present as the War Office is as much interested in saving space and man-power as is industry. It was pointed out that the more man-power could be saved by mechanical handling in the administrative branches of the Army, the more it became available for the fighting units.

TRAINING AND MAINTENANCE

The importance of training operators of fork-lift trucks and the like was stressed in a paper entitled "Operator Selection and Training" presented by Mr. A. C. Cooper during an interval between the demonstrations. This paper gave rise to questions, during the subsequent open forum session, on the relative status of the operator among skilled workers and it was conceded that, since a measure of co-ordination of faculties was essential, the fork-lift operator should be not less than 75 per cent. up the scale. It was also pointed out, during the discussion, that any pay-incentive should not be based on weight of materials moved but on a combination of weight and skill, the latter being indicated by a freedom from mishaps and damage to stores and pallets.

Mr. A. R. E. Arnot presented a short paper on the subject of "Preventive Maintenance" in which he gave some examples of how users had complained to manufacturers regarding defects subsequently found to be due to the absence of proper maintenance.

The closing address was given by Major-General H. Bainbridge, C.B., C.B.E., Deputy Quartermaster-General, War Office, who expressed the hope that there would be other conventions and demonstrations in the future at which different types of handling equipment could be seen.

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THE INSTITUTE OF METALS

Dinner in Honour of French Society

The toast of the Institute of Metals and the Non-Ferrous Metals Industries at the dinner held at Grosvenor House, Park-lane, on April 28, in honour of the President and members of the Société Française de Métallurgie, was proposed by Mr. A. D. Dodds-Parker, M.P., Joint Parliamentary Under-Secretary of State for Foreign Affairs. In his opening remarks, he stated that the Marquess of Reading, C.B.E., M.C., T.D., Q.C., Minister of State for Foreign Affairs, who was to have proposed the toast was unable to attend as he was at the conference of foreign ministers at Geneva. He said that the development in metallurgy and allied sciences since the foundation of the Institute of Metals in 1908 had been substantial and, particularly in the last few years, research had led to enormous scientific expansion in many fields. In reply, the President of the Institute, Dr. S. F. Dorey, C.B.E., F.R.S., paid a tribute to the work of French scientists in metallurgical research and, in this connection, mentioned the names of Professor Albert Portevin, Professor Pierre Chevenard, Professor Georges Chaudron and Dr. E. L. Dupuy. He also drew attention to the international character of the Institute, adding that a relatively high proportion of its members lived overseas, thus enhancing its influence and the value of its work. The real task of the Institute was to maintain a true balance between work of immediate practical importance and long-range research. The toast of "The Guests" was proposed in French by Dr. C. J. Smithells, M.C., a past President of the Institute and, in the course of his reply, Dr. E. L. Dupuy, President of the Société Française de Métallurgie, speaking in English, recalled that the Société had been founded in London during the war years as a result of a meeting of leading French metallurgists at 4 Grosvenor-gardens, S.W.1. The first general meeting of the Société had been held after the liberation of Paris in March, 1945, and the present meeting was the first to be held outside France. The members of the Société, he said, would always be conscious of the assistance they had received from British metallurgical institutions in the early formative years.

THE WORLD'S SHIPBUILDING

British Progress Maintained

The latest quarterly shipbuilding returns issued by Lloyd's Register of Shipping, 71 Fenchurch-street, London, E.C.3, indicate that the merchant steamers and motorships of 100 tons gross and upwards under construction in the shipyards of Great Britain and Northern Ireland on March 31, 1954, totalled 323 vessels, making together 2,175,760 gross tons. This represents an increase as compared with the previous quarter, of 2,051 tons. Of the total of 323 ships, 86, comprising 568,427 tons were fitting out afloat and 237, aggregating 1,607,333 tons had still to be launched. The progress made during the quarter under review is indicated by the fact that 65 ships totalling 401,143 tons were commenced, 51 vessels aggregating 314,189 tons were launched, and 53 ships comprising 403,613 tons were completed. The oil tankers under construction totalled 92, making together 1,116,998 tons, a decrease, as compared with the December, 1953, total, of 34,406 tons but representing nevertheless 51·3 per cent. of the total tonnage under construction in this country.

ABROAD

In shipyards overseas there were under construction on March 31, a total of 814 ships aggregating 3,991,242 tons, a decline as compared with the previous quarter of 129,925 tons. As has been the case for many years past, figures are not available for China, Poland and Russia. The leading shipbuilding country abroad was Germany and her total of ships under construction on March 31, was 644,631 tons. Then followed the United States with 486,953 tons, the Netherlands with 479,460 tons, Sweden with 409,376 tons, France with 402,166 tons, Japan with 357,090 tons and Italy with 304,192 tons. The totals of all other countries abroad were less than 200,000 tons. The shipbuilding activity during the quarter is shown by the following statistics. The ships commenced totalled 232, making together 828,398 tons (this figure being 463,945 tons less than that for the previous quarter), 224 ships aggregating 878,186 tons were launched and 226 comprising 945,364 tons were completed. Moreover, work has been suspended on 19 vessels totalling 34,231 tons. There were 207 oil tankers under construction abroad on March 31. The total tonnage of these was 2,325,643 or 71,860 tons less than on December 31, 1953. Nevertheless oil tankers represent 58·3 per cent. of the total tonnage of the shipping being built in overseas shipyards.

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FILM ON CORROSION

A sound film entitled "Corrosion in Action," produced under the auspices of the International Nickel Company Incorporated, the American associates of the Mond Nickel Company, Limited, Thames House, Millbank, London, S.W.1, was shown recently in London. The film deals first with the economic importance of corrosion and gives examples of the various forms of attack. After a diagrammatic explanation of electro-chemical corrosion, the role of oxygen as a promoter of cathodic reaction is depicted and methods of controlling corrosion outlined. Further interesting diagrams show the arrangements of metals in their electromotive series and galvanic action is then discussed in terms of potentials, current density and area effects. Passivity and protective films are demonstrated and the film ends with illustrations of the measures which can be taken to minimise corrosion.

AILSA SHIPBUILDING COMPANY

CONSTRUCTION OF DOXFORD ENGINES UNDER LICENCE

The Ailsa Shipbuilding Company, Limited, which was established at Troon, Ayrshire, in 1885, on the site of an earlier shipyard dating back to 1811, operated for their first 22 years as shipbuilders only. In 1907, however, they added an engine works in which, to date, more than 200 sets of marine steam reciprocating machinery have been constructed, of sizes up to 3,000 indicated horse-power. During recent years there has been an increasing tendency to adopt Diesel engines in the medium-sized vessels – up to 350 ft. long and 5,000 tons deadweight – for which the yard is laid out, and, in conformity with this trend, the company have enlarged and re-equipped their works for the production of Doxford opposed-piston oil engines up to 3,000 brake horse-power, for which they have obtained a licence from William Doxford and Sons, Limited, Sunderland. The first of these engines has completed its official full-power shop test on the newly-installed test bed, where we were enabled recently to see it running. It has been built to the order of the Burntisland Shipbuilding Company, Limited, for a vessel of about 5,000 tons deadweight, and is shown in the illustration below.

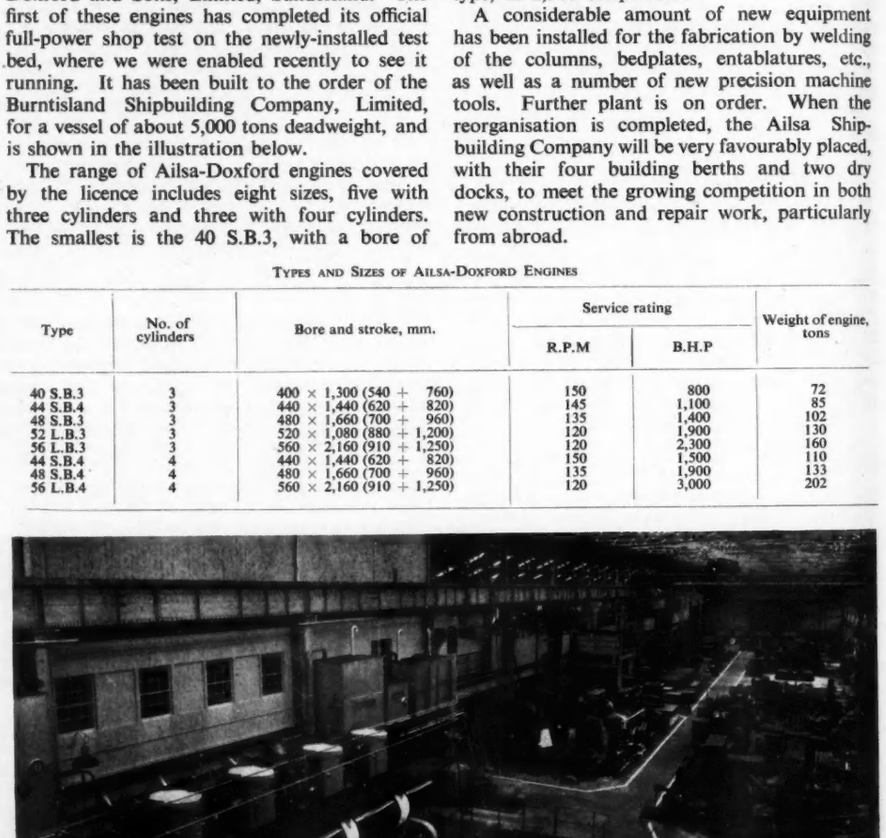
The range of Ailsa-Doxford engines covered by the licence includes eight sizes, five with three cylinders and three with four cylinders. The smallest is the 40 S.B.3, with a bore of 400 mm. and a combined stroke of 1,300 mm., a service rating of 800 b.h.p. at 150 r.p.m., and a weight of 72 tons. The largest is the 56 L.B.4, which has a bore of 560 mm., a combined stroke of 2,160 mm., a rating of 3,000 b.h.p. at 120 r.p.m. and a weight of 202 tons. The full range is given in the accompanying Table.

The engine which was demonstrated on the occasion of our visit is of the 48 S.B.4 type, and has developed on test 1,900 b.h.p. at 135 r.p.m. At this load, the fuel consumption is 7¼ tons per 24 hours. It will run on either marine Diesel fuel or boiler oil. A feature of the Doxford design is the ability to run steadily at low speeds, and we were informed that the engine had run on test at as few as 14 r.p.m. A similar engine is under construction, to develop 2,000 b.h.p., and orders are in hand for four of the 56 L.B.3 type, of 2,300 b.h.p. each.

A considerable amount of new equipment has been installed for the fabrication by welding of the columns, bedplates, entablatures, etc., as well as a number of new precision machine tools. Further plant is on order. When the reorganisation is completed, the Ailsa Shipbuilding Company will be very favourably placed, with their four building berths and two dry docks, to meet the growing competition in both new construction and repair work, particularly from abroad.

TYPES AND SIZES OF AILSA-DOXFORD ENGINES

Type	No. of cylinders	Bore and stroke, mm.	Service rating		Weight of engine, tons
			R.P.M	B.H.P	
40 S.B.3	3	400 × 1,300 (540 + 760)	150	800	72
44 S.B.4	3	440 × 1,440 (620 + 820)	145	1,100	85
48 S.B.3	3	480 × 1,660 (700 + 960)	135	1,400	102
52 L.B.3	3	520 × 1,080 (880 + 1,200)	120	1,900	130
56 L.B.3	3	560 × 2,160 (910 + 1,250)	120	2,300	160
44 S.B.4	4	440 × 1,440 (620 + 820)	150	1,500	110
48 S.B.4	4	480 × 1,660 (700 + 960)	135	1,900	133
56 L.B.4	4	560 × 2,160 (910 + 1,250)	120	3,000	202



The first Doxford opposed-piston oil engine to be built by the Ailsa Shipbuilding Company shown on the company's new test bed.

BOOK REVIEWS

Cold Formed Machine Bolts and Hexagon Nuts. Case Study Data on Productivity and Factory Performance. Prepared for the Foreign Operations Administration Industrial and Technical Assistance Division, by the United States Department of Labor. Distributed in Great Britain by the *British Institute of Management, Management House, 8 Hill-street, London, W.1.* (5*s.*)

This report is another in the series dealing with individual industries in the United States, to which reference was made in an earlier review in ENGINEERING (Hand Tools, p. 361, March 19, 1954). It follows the plan of the work mentioned, and of other reports in the series. No attempt is made to give novel technical information. Instead, the report is concerned with a detailed study of the manufacturing processes in five typical United States plants, which were chosen because they resembled as nearly as possible typical plants in this country. Two of the plants employ less than 300 workers, and only one has more than 2,500. The other two employ approximately 1,800 and 800 workers respectively. All the plants are, therefore, quite comparable in size with establishments operating in this country, and direct comparisons are possible. To this end the report sets out in detail the methods employed by the plants reviewed, and gives, in appendix form, the questionnaire which was used to obtain the information given in the text.

The major feature of the American bolt and nut trade is the use of specialised machinery, in which respect it is similar to our own. Many of the machines used in this country are, of course, of American manufacture, though there is an increasing tendency for British machines to become available. In the plants studied, both the conventional methods of bolt manufacture can be seen, and details are given of both the older method of cold-heading, trimming, pointing and threading as separate operations, and the newer "Boltmaker" method, in which all the operations are performed by a single machine. Two methods of nut making are also described: cold forming from round wire, and punching from strip. Tapping is a separate operation in both cases. The operations for bolt and nut making in the different plants are broken-down in a series of tables, details being given of the machines used, number of operators and output. Mechanical handling is prominent, as would be expected, though it is not universal, manual movement of small containers being common where the distances involved are short. The bolt and nut industry in this country is of relatively small size, and the report will be of limited interest as a consequence. Large-quantity production of any small range of articles in metal has, however, some points in common with the bolt and nut trade, and the detailed account given in the report may well prove of interest to others besides those immediately concerned with the trade.

Densening and Chilling in Foundry Work. Ferrous and Non-Ferrous Casting. By EDWARD LONGDEN. *Charles Griffin and Company, Limited, 42 Drury-lane, London, W.C.2.* (21*s.*)

Chilling, for the localised production of hard surfaces on castings, is among the oldest of the specialised techniques known to the foundryman. When it was first used is unknown, but it is recorded that iron cannon balls were being cast in moulds of the same metal in the middle of the Sixteenth Century, and there seems little doubt that the effect of chilling had been observed, and probably put to use, much earlier. Chilling was applied to rolls at least as early as 1700, when a London ironfounder advertised that he could supply rolls so hard that no file could make an impression on them. A little more than a century later, Robert Ransome, of Ipswich, revolutionised the agricultural implement industry by producing chill-cast iron plough shares. Densening, for cooling-rate control in order to improve casting soundness and density, may not have such a long history as chilling, but both techniques have been known and practised for a considerable period, and it is surprising that they should have received so little attention from technical writers. References to the subject have appeared from time to time, and in various places, but hitherto there has been no detailed treatise available. This lack of authentic information has been remedied by the publication of the present book.

The author deals at length with the metallurgical and physical factors involved in the use of chills and denseners, and considers the question of metal analysis as influencing the production of castings of the required characteristics. As a basis for his treatise the author defines densening as the application of high heat-conductivity material to areas of a mould or core which need an accelerated rate of heat transfer to balance them with other parts of the mould. Chilling is defined as using metal moulds or mould-sections to produce cooling rates in the casting which will secure the formation of white iron. There are many possible applications of both chilling and densening, and the book gives numerous examples, together with a detailed examination of the different types of densener which can be used.

A considerable part of the book is devoted to cast iron, but other metals are treated as well. There are two whole chapters dealing with steel castings, and a further two chapters on non-ferrous metals. Permanent moulds, and the process of densening by centrifugal action, are also discussed. The book is well illustrated, both line and half-tone blocks being used to good effect. The subject is one of considerable importance, and the author has done a useful service to the foundry trade by bringing together a great deal of information which was previously very difficult of access, or even impossible to obtain. It is a successful attempt to reduce to a science what has hitherto been largely a matter of empiricism. In addition to the foundryman, for whom the book is primarily intended, any engineer responsible for casting design could benefit from it, for the examples chosen to illustrate the text are all items commonly used in engineering works. Bedplates, cylinders, machine-tool castings, gear blanks, pulleys and pipes are all well-known sources of trouble to the engineer if the castings are not sound. The book discusses the steps which can be taken to ensure that sound castings will result, using as examples some of the items mentioned above.

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BOOKS RECEIVED

The Properties of Tin. Revised edition. *Tin Research Institute, Fraser-road, Greenford, Middlesex.* (2*s.* 6*d.*)

El Salvador. By A. W. D. EVES. Overseas Economic Surveys. Published for the Board of Trade, Commercial Relations and Exports Department, by *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 6*d.*)

Flow and Fan. Principles of Moving Air through Ducts. By C. HAROLD BERRY. *The Industrial Press, 148 Lafayette-street, New York 13, N.Y., U.S.A.* (4 dols.); and *Bailey Brothers and Swinfen, Limited, 46 St. Giles High-street, London, W.C.1.* (34*s.*)

Radio Research 1953. Report of the Radio Research Board. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 9*d.*)

Handbook of Industrial Electroplating. By E. A. OLLARD and E. B. SMITH. Second edition. Published for "Metal Industry" by *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1.* (30*s.*)

The Penn State Bibliography on Sprays. Compiled by the Staff of the Department of Engineering Research, Pennsylvania State University. Second edition. *The Texas Company, Refining Department, Technical and Research Division, 135 East 42nd-street, New York 17, N.Y., U.S.A.*; and *Bailey Brothers and Swinfen, Limited, 46 St. Giles High-street, London, W.C.1.* (30*s.*)

TRADE PUBLICATIONS

Diesel-Engine Starter. A leaflet describing the recent modification and additions to the "Handraulic" starter has been issued by Bryce Berger, Ltd., Ironbarks Works, Staines. A new type of pressure gauge has been fitted and an automatic charging pump is available.

Locating Earth Faults. The Cambridge Instrument Co., Ltd., 13 Grosvenor-place, London, S.W.1, have issued a leaflet describing their instruments for locating earth faults on power cables. Models are available for high- or low-tension circuits, and for Murray and Varley loop tests.

Switches and Plugs. Leaflets published by M.K. Electric, Ltd., Wakefield-street, Edmonton, London, N.18, cover their range of fused spur-boxes, switch-plugs and socket outlets.

Micro-Switches. The Burgess Products Co., Ltd., Team Valley, Gateshead, 11, have published a series of data sheets for their range of micro-switches. Complete physical and mechanical details are given.

Control Panels for Electric Motors. Brook Motors, Ltd., Empress Works, Huddersfield, have sent us an illustrated leaflet describing the panels they are manufacturing for the control of electric motors. These are specially adapted for mounting on machine tools and other machines.

Ties for Form-work. We have received a leaflet describing the "Robel" tie-rod system which is designed to facilitate the setting up of form-work for reinforced or plain concrete. The component parts are made by David Roberts and Company (Engineers), Ltd., 276 Monument-road, Birmingham, 16. The system utilises slotted wedge-shaped clamps in conjunction with plain rod-ties which are indented at site by a small hand-press at those points corresponding to the desired positions of the slotted clamps.

Smoke Indicator. Radiovisor Parent, Ltd., 1 Stanhope-street, London, N.W.1, have issued a leaflet describing their smoke indicator. It consists of a light-beam projecting unit, a light-sensitive receiver and a controlling unit which may be connected to an external indicator, recorder or alarm. The apparatus throws a light beam across the base of a smoke-stack and detects the presence of smoke before it is emitted into the atmosphere.

Calendar. We have received from the Eyre Smelting Co., Ltd., Tandem Works, Merton Abbey, London, S.W.19, a tear-off wall calendar, which is illustrated by six photographic reproductions of London scenes and is current until March, 1955. A limited number of copies are available for distribution.

Pneumatic Equipment. A catalogue of pneumatic equipment including small cylinders and valves for use in air-operated jigs and fixtures has been sent to us by Martonair, Ltd, Parkshot, Richmond, Surrey. Both single and double-acting cylinders are made, with bores of 1¼in., 1¾ in., and 2½ in., and the length of the stroke, depending upon the size of the particular model, may vary between 1½ in. and 12 in.

Wool Grease. A booklet which gives details of the technical uses for recovered wool grease and its by-products has been sent to us by the City of Bradford By-Products Department, Esholt Hall, Esholt, Shipley, Yorkshire. The grease is recovered from the wool scouring liquors which pass to the Corporation's works at Esholt. The grease contains about 60 per cent. of neutral wool grease (lanolin) and 30 per cent. of free fatty acid. It is produced in three grades: "A" the crude material; "B" deodorised; and "C" deodorised and bleached.

Self-Cleaning Strainer. The "Rotoklene" fluid strainer, which is described in a booklet issued by Ashworth & Parker, Ltd., Riverside Works, Bury, Lancashire, is capable of retaining particles 0·002 in. in diameter and can be cleaned without interrupting the flow. The strainer is wire-wound and employs wire of triangular section to give improved filtering quality.

Contactors for Alternating Current. A leaflet published by the Electric Construction Co., Ltd., Wolverhampton, gives particulars of their 25 amp. capacity four-pole contactor. Two auxiliary contacts can be fitted and the relay is designed to operate on 380/440 volts 50 cycles. The relays will withstand British Standard tests.

Lifts. Pickerings, Ltd., Globe Elevator Works, Stockton-on-Tees, have issued a booklet intended to be a guide in preparing preliminary plans for lift installations. Electric and hand-power lifts are included for both goods and passenger service.

The Institution of Naval Architects (continued from page 588)

SHIP PERFORMANCE AND MODEL PREDICTION

SIGNIFICANCE OF SURFACE CONDITION

The Spring Meeting of the Institution of Naval Architects was resumed on the morning of Friday, April 9, with the presentation of the sixth and seventh papers in the programme, these being on "Ship Performance and the Model Prediction," by Dr. J. F. Allan and Mr. H. J. S. Canham, and "Friction and Form Resistance in Turbulent Flow and a Proposed Formulation for Use in Model and Ship Correlation," by Dr. G. Hughes. The chair was again taken by Sir Charles S. Lillicrap, K.C.B. A summary of the paper by Dr. Allan and Mr. Canham is given below.

SUMMARY OF PAPER

Dr. Allan, in presenting the paper, explained that it gave the results of comparison studies of ships and their models which had been carried out in the United Kingdom jointly by the British Shipbuilding Research Association and the National Physical Laboratory. In all cases, special model tests were made to correspond with the condition of the ship on trial as regards hull form, displacement, trim, rudder and propeller. The vessels concerned were mainly single-screw deep-sea tankers and dry-cargo vessels. Performance predictions were made for a new freshly-painted vessel, moving without the use of the rudder in calm deep water, in the absence of wind. The ship data were obtained from normal shipbuilders' or owners' trials, using the code of procedure drawn up by the B.S.R.A. in 1947. In most cases, the measured-mile programme consisted of one run in each direction at each of four engine settings. Autographic records were made of time, relative wind speed and direction, and propeller revolutions. Continuous records, or, where this was not done, frequent observations were made of rudder angle; and the torque was measured on the line shafting by a Siemens-Ford torsionmeter. In some cases, the thrust was measured at the thrust block by a Michell thrustmeter; the readings were considered to be accurate to within $\pm$ 3 per cent. No trial was accepted in which the true wind speed along the course exceeded the speed of the ship, or in which there was observable pitching or rolling. The maximum recorded rudder angle was less than 5 deg.

All the models tested were in wax, about 18 ft. long, and were fitted with trip wires. For the purpose of the comparison, they were specially made to the lines, stern frame and rudder particulars of each ship as built, and the propeller models also were specially made to conform to the propellers as fitted. The main analysis was made by using the standard Froude friction data, but an additional analysis was done, using the Schoenherr friction formulation, to facilitate comparison with information published in the United States, and three results were tabulated in the paper to show the effect of the new friction formulation proposed by Dr. Hughes in the paper which was to follow that of Dr. Allan and Mr. Canham. The propulsion experiments covered a range of propeller loading at each speed of advance. It was considered that the model resistance curves determined at the National Physical Laboratory were accurate to within $\pm$ 1 per cent., and the propulsive coefficients to within about $\pm$ 1½ per cent.

The ship trial results were examined from the point of view of procedure on the measured mile, tidal analysis, wind and weather, accuracy of power measurement, and the length of time that the ship was out of dock, and were classified in two categories: Class A trials were satisfactory in all the above respects and the ships were less than 20 days out of dock, and Class B were cases in which the ship was more than 20 days out of dock at the time of the trial, but which otherwise satisfied the same criteria as the Class A trials. Hull finish was divided into five categories, namely: all-riveted, 25, 50 or 75 per cent. welded, and all-welded. In all, there were 37 comparisons of ship with model, 20 in Class A and 17 in Class B. They indicated the extreme importance of great care in the conduct of trials and the making of observations, if the results were to be of value. There was a significant reduction in the power required to propel a flush-welded ship, compared with other forms of construction; it was suggested that the reduction, as between all-riveted and all-welded hulls, was probably about 15 per cent. The results of the best trial comparison achieved were some 15 per cent. below the Froude effective horse-power, some 5 per cent. below the Schoenherr effective horse-power, but considerably above the effective horse-power derived by Dr. Hughes's new method. The indications were that the actual roughness of a clean painted ship surface might vary considerably.

DISCUSSION

Professor L. C. Burrill, who opened the discussion, said that the paper was both very interesting and valuable. At first sight, the results might well induce despair, by suggesting that the present basis for powering ships was unstable and unsound; but it had to be realised that the paper gave the comparison between self-propelled model tests and the ship. The inquiries represented a welcome development embracing tanks, naval architects and shipbuilders. There was a time when the shipbuilders, naval architects and engineers simply had to use their own judgment and to put their own correction factors on to the figures they received from the tank, but the interest taken by the British Shipbuilding Research Association and the Tank promised something more solid to go upon. From experience of analysing both trial and voyage data, he had concluded, first, that the results of single tests with self-propelled models were not always to be trusted as a guide to design. He fully recognised the value of self-propelled model tests as an indication of the hull efficiency element, but would prefer the method which, he understood, the Admiralty used, of deciding the final performance for the ship by referring to standard series data from large-scale propellers. Secondly, ship trial figures were not always reliable, but they showed where the fault lay. In his opinion, the weather effect on trials was very much more than was usually expected.

He suggested it would be well to extend the investigation by adding a comparison between the e.h.p. predicted from the model and the measured e.h.p., on either an Ayre or a Taylor standard basis. Then, on the propeller side, he would recommend the authors to compare not only their prediction from the model, but also the power and revolutions intended by the shipbuilders on trial and in service, with what was actually obtained. He could believe, for example, that the revolutions are 5 per cent. different. Finally, he thought that the investigation should include an analysis of the wake factors obtained from the ship data. That would give a valuable lead to the shipbuilders and designers in deciding what was the difference between the conditions under which the model propeller went down the tank behind the model, and the condition in which the full-scale ship proceeded. He doubted whether the effect of welding throughout was as much as 15 per cent., but did not think that sufficient was known yet for them to be able to say, one way or the other. He would have thought that it was probably something like 8 per cent.

TORSIONMETER

Mr. Ewan H. Smith found some difficulty in considering the implications of the paper, in that so many factors had to be taken into account and, after that consideration, the validity of the whole of the conclusions was based entirely on one single factor, namely, the measurement of the power developed by the machinery. Referring particularly to one ship listed, for which his firm had supplied the machinery: the Admiralty constant of 494 given for that ship was based on torsionmeter readings which, by a number of cross checks, gave at least 10 per cent. less than the horse-power which, they believed, was delivered by the engine. In that particular case, the power comparison showed that the model experiments were predicting power 15 to 16 per cent. above the actual ship performance, accepting the torsionmeter readings for the shaft horse-power. If, of course, that horse-power were accepted, which the engine-builders considered was being developed by the machinery, that particular example altered the whole perspective of such a comparison. It was well known that torsionmeters of the type used in the B.S.R.A. trials had been checked satisfactorily against dynamometer readings on the test bed, but the dynamic conditions then were very different from those which occurred in the line shafting of oil-engine machinery fitted in the after end of a ship. He felt that much of the value of the paper was invalidated by the reliance which had been placed on the Siemens-Ford torsionmeter as a scientific instrument for the measurement of output. It was an invaluable commercial instrument, but he did not think that it was accurate enough for such important conclusions as those indicated.

Another potential source of error was the assumption that the shaft losses amounted to 3 per cent. Had any attempt been made to deduce the amount of shaft friction where progressive trials had been carried out, by plotting the torque against the square of the revolutions and extrapolating to zero revolutions? That would at least have some relative value in comparing the results of sister ships which were included in the comparisons. Alternatively, a static friction test could be carried out in dry dock, with the shafting uncoupled. The paper stated that allowance was made for wind resistance. How was that correction applied for a beam wind, such as occurred so often at Skelmorlie, where more than 25 per cent. of the trials under review were carried out? The effect of a beam wind on the performance of a ship could be quite considerable. The present N.P.L. practice when predicting performance from model experiments, as stated in the paper, had no significance unless the basis from which the correction had to be made was explained. Hitherto, in N.P.L. reports, that basis had included a standard allowance of 10 per cent. for appendages, etc., which, for the all-welded ship, had then to be taken away. The power comparisons were stated to be based on Froude naked-hull effective horse-powers, without any allowances. It would be interesting to have the views of a statistician on the validity of taking the arithmetical average of the power comparison for each group as being a correct conclusion to be drawn from the results for that particular class of shell finish. It was unfortunate they had become so accustomed to use of power in the consideration of ship propulsion and resistance, instead of the aeronautical basis of torque and thrust.

Commander L. A. Rupp, U.S.N., agreed with Dr. Allan that the collection of accurate ship-trial data was a difficult and sometimes a frustrating experience. Even with the best of care, random and systematic variables crept in which were not susceptible of direct analysis. Quite often, some of the data of which those variables could be evaluated was not obtainable because of cost, lack of instrumentation, weather,

or other factors. Therefore, they adopted the statistical approach, using data from a number of trials to cancel out the random errors and hoping thereby to separate out the constant and systematic variables. There might be some danger in that approach if there were too many unknown systematic variables, and the one that was selected for statistical analysis might be interrelated with other factors, and might not be the most influential one. As an example, the authors endeavoured to separate out the frictional resistance effects associated with hull structure, varying from all-riveted to all-welded construction, and concluded that the reduction in power for the total change from all-riveted to all-welded construction was probably about 15 per cent. N.P.L. practice in predicting performance increased that figure to 20 per cent. He believed that deduced difference might be too great on the basis of the trial results shown, and in view of the lack of correlative data for the actual surface or paint roughness of the vessels concerned. For instance, in considering the all-riveted ships, Ship No. 56 required 8·3 per cent. less power than predicted, even though it was one of the ships on the Class B list.

Several freshly-painted all-welded ships had from 3 to 5 per cent. greater resistance, compared to the model prediction. That discrepancy was much greater than the acknowledged maximum liability to error in the trial data. Therefore, he believed that a statistical analysis of resistance, based only on structural roughness of the hull as a variable, might be misleading.

TORSIONAL MODULUS

Under "Ship Trial Factors," the authors stated that a torsional modulus of $11{\cdot}95 \times 10^6$ lb. per square inch was used for all the trials. Compared with experience from shaft calibrations in the United States, that figure agreed quite well with the average modulus values for carbon-steel shafts, but additions of alloying elements might introduce appreciable variations. Nickel additions depressed the modulus, and some other normal alloying elements increased it; the average modulus of a 2½ per cent. nickel shaft was 3 to 4 per cent. less than for carbon steel, and the modulus for a low-alloy molybdenum-vanadium steel was about 2 per cent. greater. Concerning bearing losses, the paper stated that a "standard" reduction of 3 per cent. was taken from the measured shaft horse-power to obtain the developed horse-power at the propeller. How was that standard figure derived? He was of the opinion that it might be too great. About 20 years ago, careful tests were carried out to determine the bearing losses on a destroyer in the United States. The shaft was uncoupled from the gear and was driven by a small shaft on which a torsionmeter was mounted. A lead dummy hub, of weight equal to the propeller, was fitted to give comparable bearing loadings. At the design revolutions per minute the total power losses from three outboard water-lubricated lignum vitae bearings, three oil-lubricated steady bearings, and a stern-tube stuffing-box amounted to only one quarter of 1 per cent. of the full power. Even assuming the losses at 1 per cent. for a single-screw merchant ship, the ship-model resistance correlation plots given in the paper would be raised 2 per cent., and nearly all the Class A trial results would lie above the Schoenherr line. Also, that change would bring the average thrust and power results more nearly in line with each other.

With the information now available, a ship designed by an experienced naval architect probably could not be improved more than 5 per cent. by extensive model testing. But what happened after the hull design was fixed? Variations in paint applications or other built-in surface roughnesses could overshadow all the gains from extensive design studies and model testing efforts, which was difficult to believe from visual inspection alone, though considerable evidence confirmed it. From the ship point of view, the real effort must be to minimise the shaft horse-power, integrated over the full period of time between routine dockings. He concurred with the remarks of previous speakers on the requirement for wake analysis in trial data, and thought that the hull frictional surface roughness effects would be brought out by wake analysis; at times, they had shown ship wakes to be considerably greater than model wakes. That might account for some of the discrepancies mentioned in model propeller r.p.m. prediction. He believed that development of methods of providing better control of paint roughness, coupled with optimum anti-fouling properties, offered the greatest scope for improvement in ship performance.

CAVITATION

Mr. J. L. Bessant said that the accurate prediction of ship performance from the results of model experiments had been for many years a primary objective of the Admiralty Experiment Works at Haslar. A full description of the Admiralty method of analysis was given by M. P. Payne in a paper read before the Institution in 1934, and there was a further reference, dealing particularly with the cavitation aspect, in a paper by Dr. R. W. L. Gawn before the North-East Coast Institution in 1949. The method differed in a number of respects from that employed by the authors. In particular, it was not regarded as satisfactory to rely on propeller efficiencies determined from the model; instead, they were determined from a large-scale methodical series of propeller tests. It was possible that both the scatter and the quantitative deductions might be influenced by propeller scale effect. The ranges of interest for merchant ships and warships, while parallel, would seldom overlap. Warships were generally characterised by finer forms, higher speeds and multiple screws so that, compared with merchant ships, skin friction and hull roughness were a little less important, hull efficiency elements were smaller, and the effects of shallow water and cavitation were relatively more important. There was, however, considerable common ground in analysis, and there might be something to learn by applying Haslar methods of analysis to the wealth of ship-trial and model-experiment data now made available in the paper.

TRIAL RESULTS

In connection with that scatter, which appeared to amount to as much as 25 per cent., it was clear that the reasons must lie largely, if not entirely, at the ship end; and no change of technique of model experiment or trial analysis was likely to dispose of it or to reduce it appreciably. It was tempting to blame the restricted scope and lack of precision of trial records, which were undoubtedly responsible in part, in spite of the effective control instituted by the B.S.R.A. in their code of procedure for trials. No one could be expected to predict the trial results within $\pm$ 5 per cent. in power. Further, until substantial improvement was made in trial accuracy, and in allowing for trial conditions and hull and propeller conditions, it was unlikely that the ship trial could give guidance in the matter of the particular formulation to use, if they were dissatisfied with Froude, to calculate the ship skin friction. The authors had made a commendable effort to bridge the scatter by a series of steps graded to the degree of structural finish of the shell; there was good evidence to show that structural finish was an important parameter, and warship experience supported that view. Clearly, too, the roughness of the hull surface, and of the propeller and the hull fouling, were factors for which, in the absence of data, no allowance had been made. It was of interest that, by comparing the Class A trials as a whole, which were, on the average, seven days out of dock, with the Class B trials, which were 61 days out of dock, it could be concluded that the e.h.p. was increased by one-fifth of one per cent. per day out of dock. He asked what evidence there was to support the standard reduction of 3 per cent. which had been applied to the measured s.h.p. to obtain the d.h.p. at the propeller.

Professor E. V. Telfer said, with regard to Dr. Allan's preference for the double-run method of conducting a trial, that he fully agreed with him, but would go farther and recommend, as the result of much analysis work, that there should be a single run at different revolutions right up the scale, culminating in the final contract speed at the double or single run, as the owners might prefer. That gave much information, and the need for such information was clearly endorsed by the paper. Speakers had referred to the value of 3 per cent. as a standard reduction for the shaft transmission efficiency. He strongly recommended that work of that nature should always be preceded by a consideration of the generalised power diagram for each ship. In 1952, in a paper on ship-model correlation, he stated that over-estimates of the order of 30 per cent. in the power necessary for ships were not unknown. Remembering that, at the Teddington tank, they did not start from zero on the diagram in the authors' Fig. 1, but from zero plus 10, he was not sure that he was exaggerating. On the question of scale effect, the authors considered the possible merits of the Hughes proposal. Taking the two right-hand columns in their Table III, which gave the prediction from the Hughes line, for the tanker S15, if power measurements were used, the percentage of ship e.h.p. above the Hughes line was 18·6, and if thrust measurements were used the percentage was 32·5. It was perhaps unfair to Dr. Hughes to make such a comparison, in view of the scale effect in thrust deduction, and in the case of single-screw ships the thrust deduction became smaller as the model size increased; so that the 32·5 per cent. was an over-estimate.

FUTURE TRIAL DATA

Mr. A. Silverleaf recalled that, as a student, and subsequently in industry, he had a naive, though understandable, belief that there was a very considerable body of ship-trial data available on which ship-model comparisons could be securely based. On going to the N.P.L. he had found that, prior to the initiation of the very extensive series of ship-trial calculations by the B.S.R.A., the amount of data available for making comparisons was very small. At the N.P.L. they had to provide predictions for all classes of vessels. It was a pity that the types of vessels described in the paper and in various reports were very restricted in range. For some classes of vessels in respect of which they received numerous inquiries, and which represented a substantial number of ships, the amount of trial data available was still almost nil, and he felt that the provision of the information required depended mainly on the acquisition of future trial data.

Mr. Canham, replying to the discussion, said that reference had been made by Professor Burrill to the effect of weather on trials. That was one of the things which, he thought, would come out in the course of the investigation; as more reliable ship-trial data accumulated, they might also determine from it, to a far greater extent, the effect of weather. Various speakers had referred to wake factors. It would be seen from the paper that the amount of thrust measurement was small; in the future they would attempt to get much more transmission data. The shaft-loss deduction applied to the horse-power, he thought, would call for a certain amount of conservatism. As to the adoption of, or adherence to, the value of 3 per cent., it was sufficient to say that they had considered the matter and were still considering it. He did not see any point in trying to obtain that value by extrapolation. In the great majority of trials they had attended, the lowest power setting was of the order of 60 per cent., and the range was usually 60 to 100 per cent.; therefore, there was a very great range to extrapolate, and he thought it would be agreed that, in view of the degree of accuracy obtained, it was hardly justifiable. In reply to Commander Rupp: they had confined themselves to the effect of welding simply because no information on surface roughness was available.

To be continued

NEW METALS IN ENGINEERING*

By Dr. L. B. Pfeil, O.B.E., F.R.S.

In marine engineering, as in other industries, non-ferrous alloys are taking an increasingly prominent position. Copper-base, aluminium-base and nickel-base alloys have proved their value in many applications. Cast copper-base alloys, such as gunmetal and high-tensile brass, are widely used in marine engineering for the production of such components as propellers, stern tubes, shaft liners, pump bodies, valves, etc. Many of these castings are large, of heavy section, and play an important part in both the initial and running costs of a ship, yet little information is available to the designer regarding their mechanical properties.

One of the important factors that influence the mechanical properties of castings is the effect of section-thickness upon strength and ductility. The properties obtained from separately-cast test bars provide only a guide to the quality of the metal going into the casting; they do not establish the properties of the casting itself. W. J. Reichenecker† has recently published the results of an investigation showing how some of the more commonly used copper-base alloys are affected by casting section. In this work he employed a step-bar casting having a section varying from ⅛ in. to 2 in. in thickness, and mechanical properties were determined on tensile specimens machined from the different sections. All the alloys examined showed a decrease in mechanical properties with increase in section thickness. High-tensile brass and aluminium bronze were the least affected by variations in section-thickness; gunmetal and tin-bronze alloys were affected to a greater degree.

In order to obtain further information on this matter, investigations have been undertaken recently in the laboratory of the Mond Nickel Company, Development and Research Department, using a similar form of step-bar casting. From the results it may be deduced that increasing the section-thickness from 1 in. to 2 in. of a casting in 85/5/5/5 (copper : tin : zinc : lead) gunmetal does not necessarily double the load-carrying capacity of the section and, conversely, a reduction of section is not necessarily accompanied by a proportional loss of strength. The tensile strength of 85/5/5/5 gunmetal decreases from about 16 tons per square inch in a 1-in. section to 12 tons per square inch in a 2-in. section. This decrease in tensile strength is accompanied by a marked reduction in ductility. It is quite possible that, as the casting section increases above 2 in., these changes may become even more pronounced: this aspect is receiving further attention.

If 2 per cent. of nickel is substituted for an equal amount of tin in 85/5/5/5 gunmetal, different results are obtained. The mechanical properties of the casting do not now decrease as the section is increased and both tensile strength and elongation remain reasonably constant.

With some alloys, particularly those susceptible to precipitation-hardening on slow cooling, mechanical properties may actually improve as the casting section is increased. This tendency is shown by high-tensile aluminium bronze containing 9 per cent. aluminium, 5 per cent. iron and 5 per cent. nickel; it explains to some extent why alloys in this group have been increasingly employed during recent years for the manufacture of marine propellers. High-tensile aluminium bronze is superior to ordinary aluminium bronze and to high-tensile brass, both as regards resistance to erosion and the maintenance of mechanical properties in castings of heavy section. Unfortunately, within the compositional limits normally employed, alloys in the aluminium-bronze group are much more difficult to handle in the foundry, and this has undoubtedly restricted their development, particularly in so far as the production of large castings is concerned.

Recently, however, alloys of modified composition have been introduced, in which the troubles associated with the founding of aluminium bronze have been largely overcome. Large castings, such as propellers, can be produced in these alloys without difficulty, up to weights limited only by plant capacity, and the castings are found to be clean and exceptionally sound. Furthermore, a fine grain size is maintained, even in heavy sections, resulting in sounder metal in these sections and less scatter in mechanical properties throughout the casting. Among the new alloys of this type is that developed by J. Stone and Company, Limited, under the name of "Novoston."*

GRAPHITIC NICKEL

In a magnesium-free cast nickel alloy containing carbon 1, silicon 2·30, and manganese 1·5 per cent., graphite occurs solely in flake form, but when small amounts of magnesium are added the graphite structure is altered. At low magnesium levels the graphite occurs as a mixture of flake, nodules and spheroids with radial structure, but with more magnesium present, the graphite is converted to a predominantly spheroidal form, with associated rise in tensile strength and ductility. A typical composition of a fully-spheroidal-graphite alloy is carbon 1-2·5, silicon 2, manganese 1·5 per cent., with magnesium 0·05-0·15 per cent. in excess of sulphur, the balance being nickel; it has a tensile strength of about 26 tons per sq. in., with an elongation of about 22 per cent., and shows excellent non-galling properties. Addition of tin to this type of alloy still further increases the tensile strength and enhances the resistance to seizure on rubbing contact, but the toughness is somewhat lowered by the presence of tin. In the tin-containing modification, the optimum combination of mechanical properties and gall-resistance is secured in an alloy containing carbon 1, silicon 2, manganese 1·5, tin 2·5-4 per cent., with 0·1 per cent. of magnesium in excess of sulphur, balance nickel. The alloys cast easily into pressure-tight shapes and have good surface quality. Their use in marine engineering and other fields calling for mechanical strength and resistance to corrosion, galling, and wear appears likely to increase as the materials become better known.

SPHEROIDAL-GRAPHITE CAST IRON

In a paper presented to this Institute by M. M. Hallett in 1951, an account was given of spheroidal-graphite irons produced by the magnesium process and of their potential value in the marine as well as other fields. Since that date considerable further advance has been made with this process, and the rapidly expanding applications of S.G. iron include several which are of major significance to marine engineers.

An indication of typical properties is given in Tables I and II. Reference to these tables demonstrates the striking increase in impact-resistance which has been achieved in the new irons, a feature which renders them suitable for many parts in which shock-resistance is a primary consideration and for which, therefore, flake-graphite irons could never be considered. In conjunction with these mechanical properties it is of interest, with regard to service in the marine engineering field, to note that the resistance of spheroidal-graphite cast iron to corrosion by sea water is equal to that of flake-graphite iron. The marine engineer has thus at his disposal a material offering properties which in many respects combine the advantages of steel and cast iron. These advantages are being increasingly recognised, and S.G. iron is likely to play a useful part in marine-engineering development in the near future.

HEAT-RESISTING MATERIALS

Much research has been carried out on the possibilities of producing gas-turbine blades with axial holes for air cooling. It is well recognised that, if high efficiency is to be obtained, the least possible quantity of cooling air must be used. This points to the merits of a large surface area and small cross-section for the cooling passages.

Casting and sintering are two methods that have been tried for the production of turbine blades with a large number of small-diameter cooling passages. For highly-stressed parts operating at high temperatures, castings suffer from the disadvantage of being less uniform in properties, and hence less reliable than forgings, while the art of sintering has not yet been developed to the degree permitting mechanical properties to be obtained equal to those exhibited by wrought products of the same composition.

An interesting and promising recent development is the production of hollow blades by hot extrusion. In this process the heat-resisting alloy billet is drilled with the desired number of holes having the necessary shape and location. These holes are then plugged with an appropriate material. The billet is extruded to give the required section, and the plugs are removed by treatment in acid. Naturally, the plug or core material must be such that it deforms satisfactorily during extrusion, and dissolves readily in an acid which is non-corrosive towards the blade material.

Where taper or twist is required, further working operations may precede the removal of the cores. Where blades with an integral root are required two extrusion operations are applied. Firstly bar, having a cross-section near to that of the root, is extruded. This bar is cut into slugs which are re-extruded singly, using a die corresponding to the desired blade section and with an arrangement to stop the press so that the metal necessary to provide the integral root remains in the container. Such blades may be subjected to a drop-forging operation before the removal of the cores.

It appears to be an economic procedure to produce hollow blades by this technique, with passages limited in number, size and shape only by the operations involved in machining the original billet.

The application of extrusion to high-temperature alloys has opened up a wide field for further advancement. The metallurgist is faced with the demand for alloys which will be stiff at high service temperature and yet be amenable

TABLE I.—*Properties of S.G. Iron, As-cast and Annealed, compared with High-Duty Flake-Graphite Cast Iron*

Property	High-Duty Flake-Graphite Cast Iron	S.G. Iron	
		As Cast	Annealed
Tensile strength, tons per sq. in.	18-22	35-45	27-35
Yield point, tons per sq. in.	—	25-35	20-25
Elongation, per cent.	nil	1-5	10-25
Transverse rupture stress, tons per sq. in.	38-42	55-65	55-60
Compressive strength, tons per sq. in.	60-65	65-80	48-58
Compressive yield strength, tons per sq. in.	—	32-40	24-32
Elastic modulus, millions of lb. per sq. in.	18	25	25
Brinell hardness	210-240	230-280	140-180
Impact Izod ,10 m.m. sq. notched, ft.-lb.	1	4	12
Endurance limit unnotched, tons per sq. in. ±	8·5	13-18	11-13

TABLE II.—*Properties of some Alloyed Irons*

Matrix	Acicular		Austenitic	
Graphite Form	Flake	Spheroidal	Flake	Spheroidal
Tensile strength, tons per sq. in.	26-36	40-60	10-14	24-27
Yield point, tons per sq. in.	—	30-40	—	15-16
Elongation, per cent.	Nil	Up to 5	1-2	10-20
Brinell hardness	250 to 350		140 to 200	
Impact, Izod 10 m.m. sq., notched	—	4	4·5	12

* Paper read before the Institute of Marine Engineers on Tuesday, April 27, 1954. Abridged.

† See *Materials and Methods* vol. 38, page 80 (July, 1953).

* See ENGINEERING, vol. 175, page 326 (1953).

to hot-working, so as to develop the characteristic merits of a wrought structure. Service temperatures have been continuously rising, with a corresponding reduction in the difference between the operating temperature, when the material must be stiff, and the forging temperature at which the material must be readily malleable. Furthermore, higher operating temperatures demand higher alloy contents, which involve a reduction in forgeability. A stage is being approached where alloys for still more onerous service cannot be forged economically by normal techniques.

Fortunately, extrusion is a less severe operation than forging, the metal being well supported as it is deformed. The danger of cracking is thus reduced, and once the coarse-grained cast structure of the ingot has been broken down, forgeability is greatly improved and ordinary hot- and cold-working operations may be applied to give the desired finished dimensions.

Nimonic 90, a well-established gas-turbine blade alloy, has the composition: chromium 20, cobalt 16, titanium 2½, aluminium 1¼ per cent., balance nickel. The combined contents of titanium and aluminium (3¾ per cent.) primarily determine the stiffness of the alloy at high temperatures, but are also responsible for the difficulties in hot-working. When the initial breakdown of the ingot is done by extrusion, it has been found that the titanium + aluminium content can be raised to levels exceeding 5 per cent., and this points to wrought alloys becoming commercially available which will withstand considerably more onerous service than those currently employed.

The recent introduction of Nimonic 95 represents a step in this direction. In this alloy the titanium content is designed to be 3 per cent. and the aluminium content 1¾ per cent. – a total of these stiffening additions of 4¾ per cent. The normal composition is thus – chromium 20, cobalt 16, titanium 3, aluminium 1¾ per cent., balance nickel. By virtue of the higher titanium + aluminium contents, Nimonic 95 exhibits properties equal to those of Nimonic 90, but at a temperature about 25 deg. C. higher. The alloy gives valuable short-term service at 925 deg. C. but the long-term properties have not, of course, yet been determined.

HARD-SURFACING MATERIALS

A relatively recent development which appears to have far-reaching practical interest in the marine field is that of hard-surfacing, with materials which will withstand corrosive, erosive, and high-temperature conditions. Welded-on coatings of the cobalt-chromium (Stellite) type have been employed for many years for the facing of cutting tools, steam-valve seats, parts of centrifugal pumps, and other components, and an outstanding example of the usefulness of facing treatment in high-temperature engineering is provided by the coating of valve heads with 80-20 nickel-chromium alloy, the well-known Brightray coating, which has been successfully applied in the automobile and aero-engine fields.

A still more recent development of the same principle is the use of fused-on coatings, employing powder alloys of nickel-chromium base in which a substantial percentage of boron is incorporated. The nature of these alloys is such as to confer a valuable combination of hardness, and resistance to corrosion and erosion, which is well maintained at elevated temperatures. The U.S. Naval authorities have reported successful experiments in the treatment by "fused metallising" of propellers and propeller shafting, using a nickel-chromium-boron alloy containing a small percentage of silicon. The coatings were found to give good resistance to seawater attack, and the process is being developed, not only for the treatment of the components mentioned, but also for the protection of the arrester hooks of carrier-based aircraft.

The nickel-chromium-boron alloys provide hardness values similar to those obtained with cobalt-chromium alloys, and their resistance to corrosion is better, particularly in contact with softened boiler-feed waters. The main advantage in the use of the nickel-chromium-boron alloys is, however, the ease with which they can be applied. The temperature of application is considerably below that necessary for the cobalt-chromium alloys (melting points of the two types are 1,050 deg. C. and 1,175 deg. C. respectively), and the nickel-base alloys are much more fluid with the result that they can be deposited by spray-welding methods to tolerances of 0·005 in. Application is normally effected by spray gun, using powder directly, or an extruded plastic wire incorporating the powder, after which the sprayed deposit is fused by oxy-acetylene torch.

THE PHYSICS OF THE IONOSPHERE

THE KELVIN LECTURE

The 45th Kelvin Lecture, with the title of "The Physics of the Ionosphere," was delivered at the Institution of Electrical Engineers on Thursday, April 29, by Mr. J. A. Ratcliffe, O.B.E., M.A., F.R.S.* He said it would be just 30 years next December since it had first been demonstrated that radio waves could be reflected from the ionised portions of the upper atmosphere. That discovery started major studies from two points of view. The first, which might be called the engineering point of view, was to find out about the propagation of waves by studying their reflections from the upper atmosphere and to employ these investigations to improve the use of the waves. The second, which might be called the physical point of view, was to study the electrification of the upper atmosphere itself.

HIGH AND LOW FREQUENCY REFLECTION

Although 30 years might be considered a long time the investigation of the physics of the ionosphere was still in its very early stages. There were two layers in the ionosphere, the upper of which reflected high frequency and the lower, low frequency waves. There were also two layers of electrons, one at the top with a large maximum electron density and one below with a smaller density. By observing the critical penetration frequencies at which the two layers ceased to reflect, their maximum electron densities could be deduced. The uppermost layer, which was known as the F layer, was at a maximum height of 250 km., while the lowest, which was known as the E layer, was at 100 km. The critical frequency was easy to determine and information had been accumulated as to how the maximum electron density varied. This information was important because the engineer wished to know what wavelengths to use to cover certain distances. And as the result of a world wide survey made during the war it was found that the E layer behaved roughly in accordance with theory, while the F layer did everything that was unexpected.

TIME AND TRAVEL AND ELECTRON DISTRIBUTION

The ionsphere changed with the seasons and was affected by sunspots. It had been suggested that the maximum electron density might vary with the shape of the layer; and that led to the question how that shape could be studied apart from the density. If the electron density at a place was known as a function of height, then the velocity of a group of waves through that place could be accurately determined. It would therefore be possible to find the velocity up to the point of reflection, integrate it and then find the total time. If the electrical distribution were known there was no difficulty in finding the time of travel for different frequencies.

The real problem, however, was that the time of travel for different frequencies was known, whereas the electron distribution was not. The problems turned out to be analogous to a corresponding one in mechanics. For example, if balls were allowed to roll down a known hill at different speeds it was easy to determine the different times it would take them to come back again. If, however, the time taken at different speeds were known it was more difficult to find out about the hill. The problem could be solved in terms of Abel's integral equation, which could be applied to the ionosphere as well as to mechanics.

CHANGES IN IONOSPHERIC CONDITIONS

The lecturer showed a film to illustrate the changes in ionospheric conditions throughout the day and night as well as the violent movements which took place. This film was made by photographing the trace, in which there was the equivalent height, against frequency and reprojecting the changes. By studying the shape of the layers it was apparent that the outermost parts of the atmosphere were in very violent movement. There were great changes in the thickness of the layer throughout the day and the seasons, and there were also short term changes. That was one of the main lines along which the study of the physics of the ionosphere was now proceeding.

A second line of thought, which resulted in the same sort of conclusion, could be described as the study of small scale irregularities in the ionosphere. The idea had grown up that the ionosphere was producing a diffraction pattern on the ground as the result of being irradiated from it. A study of the diffracted wave which came to the ground enabled a decision to be made regarding the upper atmosphere which produced it.

A third line dealt with the outermost part of the atmosphere and introduced a phenomenon known as the "whistling" atmospheric. This was nothing but an audio amplifier, which received only audio frequencies and was connected to a large aerial with no transmitter. Investigations had led to some interesting developments, the suggested theory being that each audio frequency wave started with a strong lightning flash. If audio frequency waves were emitted from a lightning flash they would be transmitted into the ionosphere, which, being subjected to the earth's magnetic field, was non-isotropic. The waves would therefore be constrained to move along the earth's magnetic line of force and, while travelling through the ionosphere, would be dispersed in such a way that the high frequencies arrived first. The result was an atmospheric whistle.

* Mr. Ratcliffe is at the Clarendon Laboratory, Oxford.

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FILM ON COMBUSTION

The Gaumont Specialised Film Unit has produced for International Combustion, Limited, a film entitled "Combustion," which traces in detail the progress made in recent years in combustion practice, particularly as applied to steam generation. It aims to stimulate interest in the economical use of coal as a fuel.

Copies of "Combustion," which runs for 32 minutes, are available on 16-mm. film from International Combustion, Limited, 19 Woburn-place, London, W.C.1.

BRITISH NAVAL GAS TURBINES

ADMIRALTY EVALUATION OF EIGHT DESIGNS

During the past ten years, eight different types of gas turbines have been evaluated by the Royal Navy. The lessons that have been learnt from these tests and the future role of the gas turbine in naval applications were discussed in a lecture entitled " British Naval Gas Turbines," given before the Institute of Marine Engineers in London on Tuesday, April 13, by Commander (E) G. F. A. Trewby, R.N. Design details of the machines are given in Table I.

WARSHIP PROPULSION MACHINERY

Discussing propulsion machinery for warships, Commander Trewby said that all warships must satisfy the following specification: (1) minimum weight, including fuel, to meet the specified endurance; (2) minimum space; (3) good thermal efficiency over a wide power range, and particularly at cruising power; (4) reliability; (5) ease of maintenance and component replacement; (6) manœuvrability, including rapid starting and reversing; (7) ease of control; (8) low noise level and ability to withstand shock and damage; and (9) economy of strategic materials and productive effort.

The propulsion of high-speed coastal craft was an obvious field for the gas turbine. Two simple designs, the Gatric and the G2, both by Metropolitan-Vickers Electrical Company, Limited, had already been operated in naval coastal craft. The Gatric engine, three of which were ordered in 1943, was based on the F2 aircraft jet engine, but with an output turbine fitted in the tail pipe. Very few modifications to the combustion system were necessary to enable the engine, originally designed for running on kerosine, to operate on Diesel fuel. The first engine was installed in MGB 2009 (later renumbered 5559) by 1947; this vessel was the first in the world to be propelled at sea by a gas turbine.

Over a period of four years, sea trials of the Gatric were remarkably trouble-free, and demonstrated that the simple gas turbine was well suited to the propulsion of high-speed coastal craft. Although only designed for 300 hours' life, two of the engines had now been running nearly 600 hours. Compressor fouling by salt spray was overcome by fitting a distilled-water spray in the compressor inlet. Compressor blade corrosion was eliminated by replacing the anodised RR56 blades with blades of RR57. Two bearing failures occurred. It was found possible to reduce the high noise level effectively by insulation and splitters in the settling chamber and the funnel.

Residual-fuel trials carried out with Gatric engines showed that they could run at maximum temperature on a residual fuel oil for limited periods.

In 1948, a contract was placed for four larger gas turbines, the G2, based on the Beryl jet engine, with the addition of a separate power turbine driving the output shaft through single-helical reduction gearing, for installation in two fast patrol boats, Bold Pioneer and Bold Pathfinder. The gas turbines were for use at high speed only, Diesel engines being fitted for manœuvring and cruising.

Sea trials of the G2 turbines began towards the end of 1951. Serious teething troubles had been encountered, including a series of compressor blade failures, resulting from resonant vibration at low rotational speeds. The G2 compressor was closely similar to that of the Beryl Mark I, which had successfully completed an Air Ministry type test. The fact that an aircraft compressor had been cleared for flight duty, therefore, was no guarantee that blade vibration troubles would not occur when operating at low speeds.

Nevertheless, experiments with the G2 had confirmed the suitability of the simple gas turbine for fast coastal craft. The air starting system employed had proved quick and reliable, and the compressor-inlet water-spray arrangements were again successful in combating salt-spray fouling. Several failures of gas temperature recording instruments had occurred, suggesting the advisability of measuring turbine outlet, rather than inlet, temperature with a more robust instrument.

The characteristics required of gas turbines used as " booster " units for high powers, as in the MGB 2009 and the Bold boats, were similar to those of aircraft gas turbines, i.e., extreme lightness and compactness, reliability, and reasonable efficiency at high powers with minimum air requirements. Gas turbines for main propulsion machinery presented a more difficult problem. Two main-propulsion naval gas turbines, in the 5,000-10,000-h.p. range had been built and tested – the English Electric E.L.60A and the Rolls-Royce R.M.60.

The E.L.60A was ordered in 1946 to replace one set of steam machinery in the frigate H.M.S. Hotham. The main object was to obtain sea experience with a long-life gas-turbine plant at an early date, and for many reasons it was desirable that the weight of the plant should be similar to that of the steam machinery.

A simple cycle with heat exchange was adopted, the compressor turbine being in parallel with a smaller power turbine driving the alternator, only one-third of the total mass flow passing through the power turbine. Any power could be obtained by manipulating the throttle and blow-off valves without altering the speed, main flow or pressure ratio of the compressor.

Owing to manufacturing difficulties, the complete set was not ready for shore trials until September, 1951, by which time initial trials of the R.M.60 had already indicated the potentialities of a lightweight turbine. The sea trials were therefore abandoned. Nevertheless, useful experience had been gained. Although the project demonstrated that heavy gas turbines constructed on steam-turbine lines were not suitable for naval machinery, a number of components were developed which could be used in future

TABLE I.—DESIGN DETAILS OF BRITISH NAVAL GAS TURBINES

Engine		Gatric	G2	E.L.60A	R.M.60	T8	Artouste I	1,000 kW G.T.A.	Emergency G.T.A.
Maker		Metropolitan-Vickers Electrical Co., Ltd.	Metropolitan-Vickers Electrical Co., Ltd.	English Electric Co., Ltd.	Rolls-Royce, Ltd.	Rover Motor Co., Ltd.	Turbomeca (Blackburn and General Aircraft Ltd.)	W. H. Allen, Sons and Co., Ltd.	W. H. Allen, Sons and Co., Ltd.
Maximum power at 15 deg. C. (60 deg. F.) air inlet temperature, h.p.		2,500	4,500	6,500	5,400	200	276	1,512	200
Duty		Boost propulsion	Boost propulsion	Main propulsion	Main propulsion	Craft propulsion	Utility	Main generator	Emergency generator
Turbine inlet temperature at maximum power, deg. C.		750	800	704	827	847	800	650	750
deg. F.		1,382	1,472	1,299	1,521	1,557	1,472	1,202	1,382
Overall pressure ratio		3·5	4·0	4·02	18·5	4·0	3·7	4·25	2·65
Air flow at maximum power, lb. per sec.		47·5	65·6	128	64·6	3·5	4·75	37·1	5·7
Thermal efficiency at maximum power		12·8	17·2	20·4	20·4	12·5	13·75	19·75	12·9
Thermal efficiency at 50 per cent. power (actual test values)		9·5	13·4	17·75	22·6	9·2	9·8	15·6	7·5 (design values)
Specific weight, lb. per h.p. at maximum power, including reduction gearing		2·77	2·28	27·2 excluding bedplates	5·3	2·25	0·78	10·5	3·0
Designed life of hot parts, hr. (based on creep data)		300	1,000	10,000	1,000	800	500 (estimated)	50,000	1,000
Compressors	Number and type	1 axial	1 axial	1 axial	One l.p. axial one h.p. 2-stage centrifugal	1 centrifugal	1 centrifugal	1 axial	1 centrifugal
	Number of stages	9	11	15	11/2	1	1	13	1
Turbines	Number and type	2 axial	2 axial	2 axial	3 axial	2 axial	1 axial	2 axial	1 radial
	Number of stages	2/4	1/3	6/6	1/2/2	1/1	2	2/1	1
	R.p.m. ÷ 1,000	7·4/3·6	7·83/5·2	4/5·6	15/11/7·18	40/35	35	8/6·75	23·5
Number of intercoolers and thermal ratio		None	None	None	3 (l.p. 2 in parallel): l.p. 86 per cent., h.p. 64 per cent.	None	None	None	None
Heat exchanger thermal ratio, per cent.		None	None	78	48 at full power with bypass open	None	None	70	None
Number and types of combustion chambers		1 annular	1 annular	6 cans	2 cans	1 single can	1 annular	8 cans	1 single can

designs, notably a highly-efficient compressor and an effective system of air-cooling the turbine rotor and blade roots.

Two R.M.60 gas turbines, also ordered in 1946, were for installation in the gunboat Grey Goose. In the R.M.60 a high-pressure ratio necessitating a complex cycle was employed. An 11-stage axial-flow low-pressure compressor discharged through twin intercoolers arranged in parallel, to a two-stage high-pressure centrifugal compressor with an intercooler between the stages. The high-pressure compressor discharged to a U-tube type heat exchanger incorporating a partial by-pass valve on the gas side. From the heat exchanger the air was led to twin combustion chambers and thence to a single-stage high-pressure turbine. The gases then passed to the intermediate power-turbine and the low-pressure turbine, the output shaft from the former passing through the high-pressure turbine and compressors. The adoption of aero-engine practice for many components resulted in a light, compact power unit. Two years' development running of the complete engine commenced in June, 1951, during which time 1,100 running hours were amassed. Sea trials of the Grey Goose were expected to commence shortly. The installation would result in a considerable increase in power with a reduction of 50 per cent. in the machinery weight.

Among the problems encountered during the shore trials – which were most satisfactory – were a limitation in rapid manœuvring, several ball and roller-bearing failures, sensitivity to ambient temperatures, a tendency to carbon formation in the heat exchanger, and a high noise level.

The shore trials had established that the R.M.60 engine, developing a power of 5,400 h.p., with a specific weight of 5·3 lb. per shaft horse-power and a fuel consumption below 0·65 lb. per shaft horse-power per hour, had suitable characteristics for a number of naval vessels. At present, however, its life of 1,000 hours limited its use to coastal craft. To improve the life and reliability, plain journal and thrust bearings would be necessary, causing increased weight and mechanical losses.

PROPULSION MACHINERY FOR SMALL CRAFT

Propulsion machinery for small craft such as landing craft and ships' boats normally operated at a high percentage power with occasional bursts of full speed. To gain experience with small gas turbines for use in such craft, four experimental Rover T.8 engines were ordered in July, 1950. The T.8 gas turbines operated on a simple cycle with an independent power turbine driving through an integral gearbox. Delivered in 1951, one engine was installed in a 52½-ft. harbour launch, and the other three were shore-tested at the Admiralty Engineering Laboratory.

The mechanical performance of the T.8 was satisfactory; throttle response was excellent and vibration virtually non-existent at all speeds and loads. Excessive lubricating-oil consumption, which necessitated the removal of the turbine from the harbour launch after 90 hours' running, and was encountered on all the engines, was remedied by redesigned oil seals. A modified gas turbine had been re-installed in the launch and trials were continuing. The sole major disadvantage of the small gas turbine appeared to be its high fuel consumption.

Two Turboméca Artouste I engines were ordered in 1952 for testing at the Admiralty Engineering Laboratory. They were of standard design, with centrifugal compressor, annular combustion chamber and axial flow turbine, with a built-in reduction gearbox; 750 hours' running had now been completed. Preliminary results had indicated that the Artouste was capable of stable operation over the whole power/speed range likely to be required for generation or propulsion applications. Combustion with gas oil was smoke free and stable with no carbon deposit.

The ignition system was modified to allow starting on gas oil, and a hand starting system was developed. An additional propeller-pitch control unit was incorporated to safeguard the turbines against damage by unskilled operators.

The noise level was unacceptably high. Routine maintenance was small and lubricating-oil consumption negligible. On stripping, the only serious defect found was scaling of the turbine blades and casings, which, it was considered, could be overcome by manufacturing them in normal British materials. Many more running hours were required to establish life and reliability.

AUXILIARY MACHINERY

Discussing auxiliary machinery, Commander Trewby said that, compared with steam turbo-generators, gas-turbine installations were expected to have reduced weight and space, would be independent of steam supply, and would provide quicker starting. Compared with Diesel generators, again they would be lighter and more compact, would require less maintenance, would run on light load for long periods, and had a reduced lubricating-oil consumption. Disadvantages were the comparatively large inlet and exhaust ducts required, and the high fuel consumption – nearly double that of a Diesel engine. Moreover, distillate fuel was at present necessary.

A contract for a 1,000-kW gas turbo-generator was placed with W. H. Allen, Sons and Company, Limited, in 1948. A comparatively simple open-cycle set was designed with an axial compressor driven by a two-stage turbine, an annular heat exchanger, a symmetrical multi-chamber combustion system, and a single-stage power turbine driving the alternator through Allen-Stoeckicht epicyclic gearing. Plain bearings were used throughout. To assist the speed governor during sudden load changes, a small flywheel was fitted on the turbine output shaft and the compressor was designed with a low moment of inertia.

Full speed, full load and overload trials were carried out in the first series of tests, which started in 1951, with a minimum of teething troubles apart from mechanical defects in the heat exchangers. This initial experience indicated that a reliable and comparatively efficient machine could be developed for an all-up weight (gas turbine only) of 10·5 lb. per horse-power. An order had therefore been placed for two additional 500-kW Allen gas turbo-generators for installations afloat.

In 1951 the Admiralty placed a contract with W. H. Allen, Sons and Company, Limited, for a gas turbine suitable for driving a small emergency generator. An extremely simple, robust and durable gas turbine had been produced. (An article on it will be found in this issue of ENGINEERING.)

In conclusion, Commander Trewby said that the gas turbine could pack more power into less weight than any other prime mover. For this characteristic an open cycle was essential, and the engine must be constructed on lightweight lines. For naval applications, however, the gas turbine required to be more robust than the aircraft turbine, and plain bearings were desirable. It could ultimately be made superior to all other prime movers in reliability and ease of maintenance. Where economy at low power was wanted, a more complex cycle with heat exchange and intercooling was necessary.

Disadvantages of the gas turbine were its sensitivity to ambient temperature, the large duct sizes necessary which were a source of structural weakness and vulnerability, and the high noise level; the latter, however, could be overcome. The burning of residual fuel in gas turbines presented formidable problems, but by controlling combustion and using small quantities of additives it might be possible to reduce deposition and corrosion to acceptable limits. Some external means of reversing was essential.

In major warships, the first applications would be as " boost " units for use at high powers with steam turbines or Diesel machinery for cruising. Later, gas turbines might become the sole means of propulsion in some warships, and in landing craft and ships' boats in the near future. Gas-turbine generators would be used increasingly, and gas-turbine portable pumps for fire fighting and salvage. Other possible applications were for boiler blowers, de-icing equipment, and the provision of low-pressure air for salvage work.

* * *

RIMUTAKA TUNNEL " HOLED THROUGH "

New Zealand Contract a Year Ahead of Schedule

Rimutaka Tunnel, 5½ miles long, for a railway through the Rimutaka Mountains of New Zealand's North Island, was " holed through " on April 20, more than a year ahead of schedule.

This has been announced by the Morrison-Knudsen Company of New Zealand, Limited, a subsidiary of Morrison-Knudsen Company, Incorporated, Boise, Idaho, and sponsor of the joint firms that are building the tunnel for the New Zealand Ministry of Public Works. The New Zealand associate in the project is Downer and Company, Limited, of Wellington.

Driving the 15 ft. by 17 ft. horseshoe-shaped bore was completed less than three years after tunnelling began on July 30, 1951. On April 1, only 2,000 ft. of the new tunnel arch remained to be lined with concrete.

Rimutaka Tunnel will replace a winding surface stretch of railway that climbs through the mountains on a maximum grade of 7 per cent. This steep stretch is known as the Rimutaka Incline. Here, since the line was built 75 years ago, special Fell engines, equipped with a central driving mechanism gripping a third rail, have been required to pull trains up the stiff grade. By eliminating this tortuous incline, the new tunnel will cut nine miles off the distance between Wellington and Featherston, and hours off the travel time.

Early driving of Rimutaka Tunnel was through unstable material known as " graywackie," which flowed when wet and was heavy when dry. To ease construction difficulties a small pilot drift was driven in advance of the full-sized bore. Once the top heading was driven and braced with timbers, the remaining earth was removed for the full-sized bore and the timbering completed. Reinforced-concrete rings were poured between the 10 in. by 10 in. timbers to prevent them from shifting.

Better ground was reached in September, 1953, and a fast pace of driving was maintained for the remainder of the work. Peak production for one week reached 250 ft. of tunnel driven and timbered with 208 ft. concrete-lined. The best day's driving and timbering was 47 ft., the average day 42 ft. This rapid going was attained despite the fact that the entire length of the tunnel had to be timbered, instead of only half the distance as had been expected.

TRAVERSING MECHANISM FOR PYROMETER AND PITOT TUBE

EXPLORING TEMPERATURE AND MASS-FLOW DISTRIBUTION IN GAS-TURBINE EXHAUST

By O. Delatycki, DIPL. ING., *and C. F. Kettleborough*, B.ENG., PH.D.

In preparation for full-scale research into gas-turbine combustion problems at the University of Melbourne, the use of the thermocouple and Pitot-static tube for quick traversing of the exhaust of the combustion chamber has been investigated. This article describes a traversing mechanism, developed during the course of these investigations, which enables the whole area of the exhaust to be explored in less than two minutes.

In the investigation of combustion chambers for gas turbines the necessity arises for a quick and accurate calculation of thermal efficiency. The thermal efficiency can be defined as the ratio of the measured static temperature rise to the theoretical static temperature rise.

The theoretical temperature rise depends on the calorific value of the fuel used, and the physical-chemical characteristics of the medium in which the combustion takes place (e.g., specific heats, mass, etc.) and can be calculated. The measured temperature rise is the temperature difference between the entry and exit of the combustion chamber. The determination of the temperature and mass flow of the air before it enters the combustion chamber is a relatively simple matter. In the exhaust, however, there are difficulties to overcome.

Since the velocity and temperature distributions in the exhaust from a combustion chamber are not uniform, it is necessary to determine the mean "weighted static" temperature T_m, defined as

$$T_m = \frac{\Sigma Q_n T_n}{\Sigma Q_n}$$

where Q_n is the mass flow through each segment of the exhaust, measured at its centroid, and T_n is the measured static temperature at the centroid of each segment. The temperature measurement itself presents difficulty since a thermocouple junction immersed in a stream of hot gas will read not only the "static" temperature of the gas, but also the temperature rise caused by impact friction and, usually, the radiation and heat losses from the junction by radiation and conduction to the surroundings. A further difficulty lies in reading the static temperature and pressure in the exhaust without unduly disturbing the flow, since the distribution of these may be of interest over a short period of time. The risk of melting any parts submerged in the hot gas (temperatures of up to 850 deg. C. are often encountered) is always present.

In the investigations carried out at Melbourne University, a sonic suction thermocouple, adapted from the pyrometer described in reference 5, and a pitot-static tube assembly were employed, to measure the weighted mean "static" temperature in the exhaust. The 8-in. diameter exhaust has been divided into 25 equal areas (Fig. 1). It is through the centroids of the areas that the thermocouple "snout" and the Pitot-static tube has to travel. The length of the snout and the Pitot-static tube were so chosen that the temperature and pressure would be measured in the same plane of the exhaust pipe.

The traversing gear, Figs. 2 and 3, incorporates a grooved plate, shown in Fig. 1 superimposed on the combustion chamber exhaust, which illustrates clearly that the centroid of each segment lies on the centre line of the groove. The centre line of the groove consists basically of two concentric circles connected by a suitable intermediate curve and continued by a suitable curve to the centre of origin of the basic concentric curves. A pin, arranged to slide on a rod mounted in a cradle (Fig. 2), is driven around the groove by an electric motor. This pin is rigidly attached to a horizontal bar connected to the thermocouple and Pitot-static tube assembly by means of a hinge and locking nut. This horizontal bar is constrained to move horizontally with respect to the ball-bearing guide frame which, in turn, is restricted to a vertical movement by a ball-bearing-guided vertical bar (Fig. 3). Thus the locus of the path of the thermocouple snout and the Pitot-static tube follows exactly the path of the pin in the groove. The pin is moved on from station to station – corresponding to the centroids of the subdivided areas – by an electric motor controlled by an indexing switch plate (Fig. 3) and micro-switches.

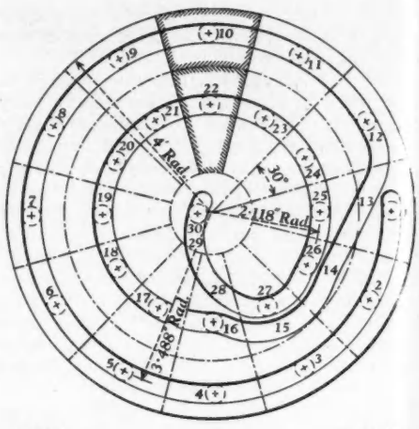

Fig. 1 Grooved guide plate shown superimposed on combustion-chamber exhaust, which has been divided into 25 equal areas for the purpose of exploring the distribution of temperature and mass flow.

The action of the electrical circuit (Fig. 4) is as follows: consider the beginning of a traverse in which the relay remains unenergised; circuit a_2^1 is closed, circuits a_1 and a_2 are open; the index micro-switch is open at commencement, micro-switches 1 and 2 of the reversing circuit are as indicated. Depressing the starting button, the circuit is completed and current flows into motor terminals A_1 and F_{R_1}. The motor rotates the indexing plate, and the tooth which held the indexing micro-switch open moves away, causing the indexing micro-switch to close, thus completing an alternative circuit so that the starting button can be released. When the thermocouple and Pitot-static tube assembly has moved into its next position, the next tooth of the indexing plate depresses the indexing switch, opening the circuit and stopping the motor. After taking the necessary readings the operation is repeated until the end of the traverse. The traversing gear runs at $2\frac{1}{2}$ times the speed of the motor and indexing plate; since the traverse is completed in $2\frac{1}{2}$ revolutions, every complete traverse corresponds to one full revolution of the indexing plate.

At the end of the traverse, a pin on the indexing plate closes the reversing micro-switch No. 1, which energises the relay, closing circuits a_1 and

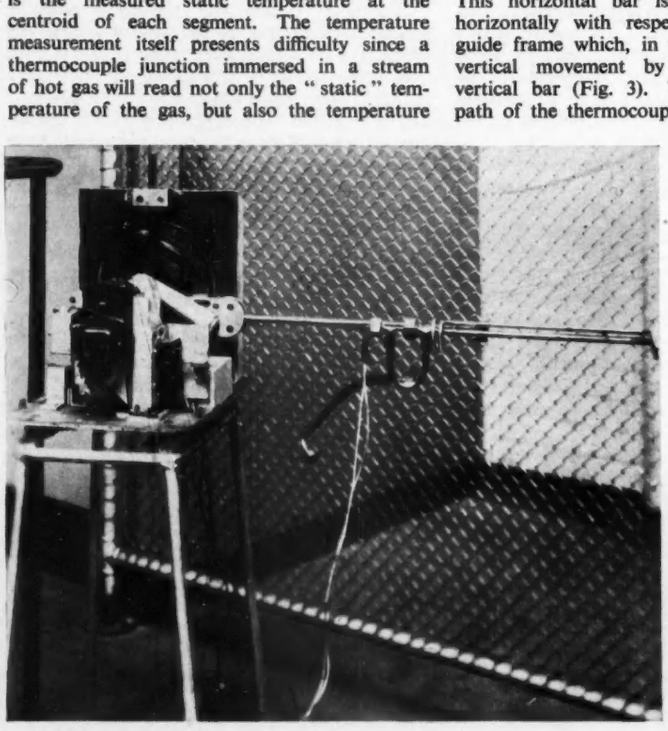

Fig. 2.

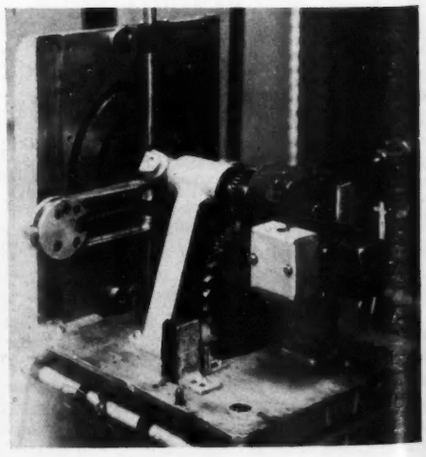

Fig. 3.

Figs. 2 and 3 Traversing mechanism for thermocouple and Pitot-static tube, which are arranged to follow the path of a pin driven round the grooved guide plate. The movement of the pin from station to station is controlled by an indexing switch plate and micro-switches.

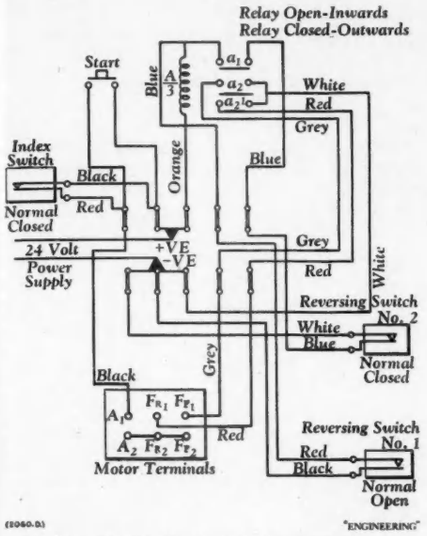

Fig. 4 Electrical circuit of traversing gear.

a_2 and opening circuit a_2^1. On depressing the starter button, current now flows to motor terminals A_1 and F_{F_1} reversing the direction of rotation of motor and the indexing plate. The reverse pin on the indexing plate now causes reversing switch No. 1 to open but reversing switch No. 2 remains closed, completing the relay circuit through a_1 so that the relay remains energised. At the end of the outward traverse the pin on the indexing plate opens reversing switch No. 2, de-energising the relay, then opening circuits a_1 and a_2, and closing circuit a_2^1. The circuit is now in the state described in the beginning of the operation and ready for an inward traverse.

Fig. 5 shows the indexing plate and associated micro-switches at the commencement of an inward traverse with the index micro-switch open and reversing micro-switches Nos. 1 and 2 closed. The teeth Nos. 13 to 15 and 28 to 30 have been removed to provide for a continuous movement from one concentric circle to the other as well as to the centre of the exhaust (Fig. 1) so that the traversing mechanism is stopped at 25 points only.

A Provision is made for swinging the thermo-couple and Pitot-static tube assembly out of the hot exhaust gases when so required by a hinge and locknut. Preliminary tests have shown that the traversing of the exhaust can be accomplished in less than two minutes, reducing considerably the time and labour required. Since the traversing can be remotely controlled, the control can be placed next to the fuel, air and other metering apparatus of the combustion chamber and the test can be supervised by one person.

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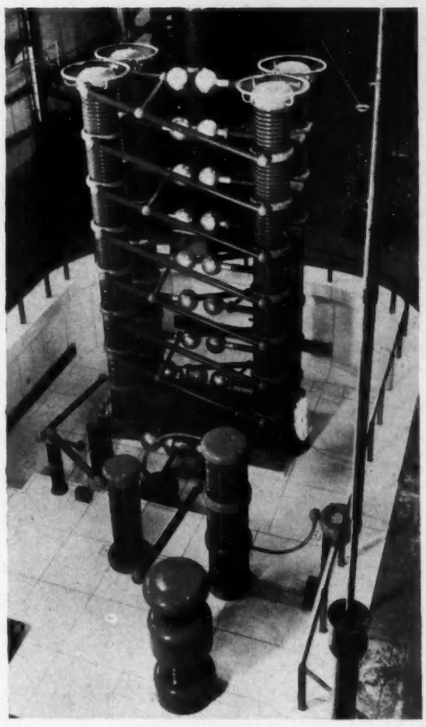
3,200-KV IMPULSE GENERATOR AT THE NATIONAL PHYSICAL LABORATORY

For many years the National Physical Laboratory has been equipped with an impulse generator with an open-circuit voltage of 2,000 kV and a stored energy of 20 kW-seconds. This consists of equipment connected according to the well-known Marx circuit, in which a number of condensers are charged in parallel through high resistances from a direct-current source and are then automatically connected in series by the breakdown of air gaps set to appropriate values. It has thus been possible to test apparatus with surges of single polarity rising to their full value in something of the order 10^{-6} second and falling to half value in 50×10^{-6} second. The apparatus has served its purpose well, but it has recently been evident that it is becoming inadequate, partly owing to the general rise in system voltages and partly due to natural deterioration after years of service. It has therefore been found desirable to replace it by equipment which is more convenient to use and is better adapted to present and future needs.

The new impulse generator which has been designed to meet these requirements is illustrated on this page and is of a size limited only by the space available in the laboratory. Its open-circuit voltage is 3,200 kV and its stored energy 77 kilowatt-seconds. The installation, including the civil-engineering work and auxiliary services, was carried out by the Ministry of Works. This department also co-operated with Ferranti, Limited, Hollinwood, who manufactured the equipment and with the staff of the Laboratory whose experience has been embodied in the design of the generator. The capacitors, which form part of the generator, were supplied by British Insulated Callender's Cables, Limited.



The National Physical Laboratory have installed this 3,200-kV impulse generator. Its stored energy capacity is 77 kilowatt-seconds; it has eight stages each with a maximum stage voltage of 400 kV.

The generator is made up of eight stages with a maximum stage voltage of 400 kV. This can be produced with an adequate margin and with either positive or negative polarity. The voltage is provided by a transformer and voltage regulator with a metal rectifier in a voltage-doubler circuit. Each stage consists of two capacitors, which are contained in separate porcelain housings, the total stage capacitance being 0·12 microfarad. The eight stages are assembled into a four-column structure, the capacitors of each column being spaced by porcelains similar to those which house the units themselves. The generator is provided with internal charging, discharge and damping resistors, while other resistors for discharge and damping are mounted externally. The electrodes of the inter-stage spark-gaps are spheres 50 cm. in diameter, and the gap spacing is controlled from and indicated at an operating desk. An external bank of capacitors constitutes a permanent capacitance load on the generator, and is the high-voltage section of a capacitance voltage divider for measuring and recording the generated surges. Provision is made for controlled electrical firing of the generator once it has been charged to the correct voltage, and for tripping the high-speed cathode-ray oscillographs before the generator itself is discharged, to give adequate time delays without the use of a long delay cable. All the controls for the generator are taken to a desk located in a glass-fronted chamber which is built out into the main laboratory at the level of the first floor of the building.

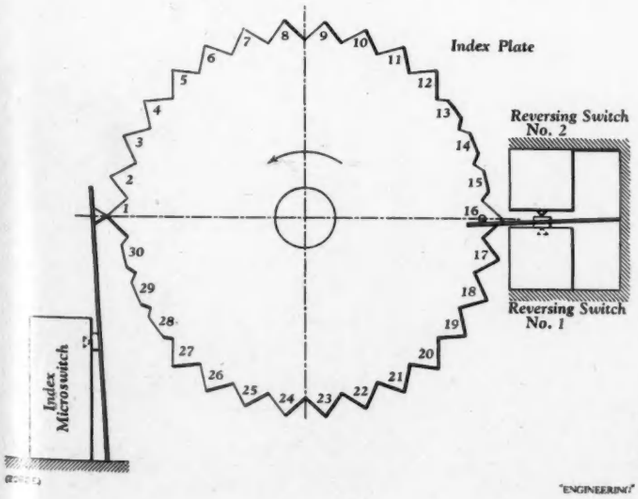


Fig. 5 Index plate and micro-switches in the starting position of an inward traverse.

A 200-TON SPRING BALANCE

WEIGHING LARGE CASTINGS FOR COSTING PURPOSES

The 200-ton crane weigher illustrated herewith is claimed to be the largest-capacity spring balance in the world. It has been designed and built by Geo. Salter and Company, Limited, West Bromwich, Staffordshire, for the English Steel Corporation Limited, Sheffield, and will be used for ascertaining the weights, for costing purposes, of heavy steel castings and forgings. The weigher is of a type which has been manufactured in many different capacities by Messrs. Salter for a number of years, but the largest capacity hitherto available has been 120 tons. Thus, while the basic design of the present weigher involved no departure from standard practice, the detailed construction, and the testing and calibration, set a number of problems.

SPRING RESISTANT

The weigher is of the Belleville washer type, having two Belleville washers, set with their concave sides opposing, to act as the spring resistant. The Belleville washers are mounted horizontally in the upper part of the main housing of the weigher, and a load-suspension rod, bearing on the top washer, passes through a clearance hole in the lower washer, to terminate in a load-supporting hook of the ram's horn type. Weights hung on the load-supporting hook cause the two washers to be pressed together. The total movement of the load-supporting hook from zero to maximum load is only $\frac{1}{4}$ in., but levers connected to the load-suspension rod and a segment-rack and pinion multiply this movement and indicate it, in terms of weight, on a dial at the front of the weigher. The dial is graduated from zero to 200 tons by 1 ton increments, with the first 10 tons blank. For suspending the weigher from the crane, there are two D-shackles, suitable for use with a ram's horn crane hook. These shackles, together with the weigher load-supporting hook, the suspension rod, and the shackle-rods passing through the body, that is, all the components in tension, are of forged steel. The body, which is subjected to compression loading only, is of high-grade cast iron.

Testing the finished weigher was carried out in two stages. As it is to be used for costing purposes, it is subject to the appropriate Weights and Measures Regulations, and it was necessary to give it a full-load test. A 50 per cent. overload test has also been applied, which was a safety test only. For this purpose the weigher was mounted horizontally in a 750-ton hydraulic testing machine at Lloyd's Proving House, Netherton, Dudley, Worcestershire. The proof load of 300 tons was applied, and the stressed components were examined and measured carefully for any permanent "set." The weigher having passed this test successfully, then had to be calibrated.

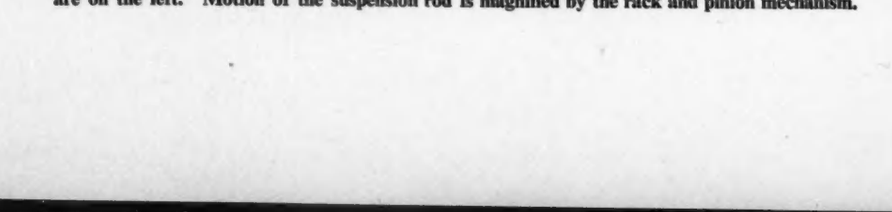
CALIBRATION AND TESTING

It is usual to calibrate weighing machines by applying actual dead weights to the load-carrying component, but such a procedure was obviously impracticable in the case of the present weigher. It was necessary, therefore, to apply the calibrating and testing load by a machine which was itself known to be accurate. Such a machine was available in the Department of Civil Engineering at Birmingham University. The machine, a 300-ton Avery hydraulic type, is maintained by the University authorities to a very high degree of sensitivity and accuracy, and is tested and verified at regular intervals by the National Physical Laboratory.

The weigher was mounted between the crossheads of the University testing machine, and calibrated up to its full rated capacity. The large size (12 ft. overall length) and weight (7 tons) of the weigher were such that its positioning in the testing machine required great care. At one point there was only 1 in. clearance between the testing machine and the weigher when the latter was being placed in position. The weight of the weigher was supported from the bed of the testing machine by rollers, and the weigher was levelled carefully. It was necessary to ensure that the load-carrying members of the weigher were perfectly free to move as the load was applied and removed, otherwise inaccuracies in calibration would have resulted.

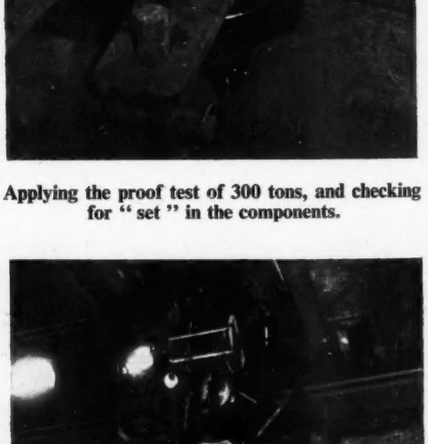
When the weigher was in position, and the supports were satisfactory, a preliminary full load test of just over 200 tons was applied. The load was then taken off, and calibration began. As each load increment was applied, the position indicated by the pointer on the dial was marked temporarily. Twelve test runs were made, the temporary markings being checked each time. The dial was then removed and sent to the makers' works for the markings to be given their permanent form.

Finally, the dial was replaced, and the weigher was submitted to an Inspector of Weights and Measures for verification. The Weights and Measures Regulations require that each numbered graduation on the dial shall be tested, and that the weigher shall indicate correctly whether the test is backwards or forwards; the standard of accuracy prescribed is approximately one part in one thousand. Several test runs were required to enable the Weights and Measures Inspector to satisfy himself that the weigher complied with these and other requirements of the Regulations. The weigher passed its tests in all respects, and was duly marked with the official stamp, which certified it for trade use.



Longitudinal section of the 200-ton spring balance. The two Belleville washers which act as the spring are on the left. Motion of the suspension rod is magnified by the rack and pinion mechanism.

Applying the proof test of 300 tons, and checking for "set" in the components.



The weigher in use, weighing a steel casting of 160 tons which has been made for a large hydraulic press.

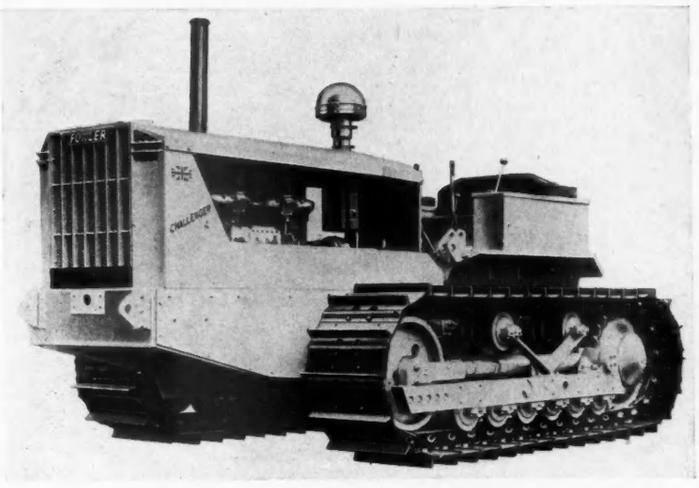


Fig. 1 Challenger 4, the largest of the range, developing 150 h.p.

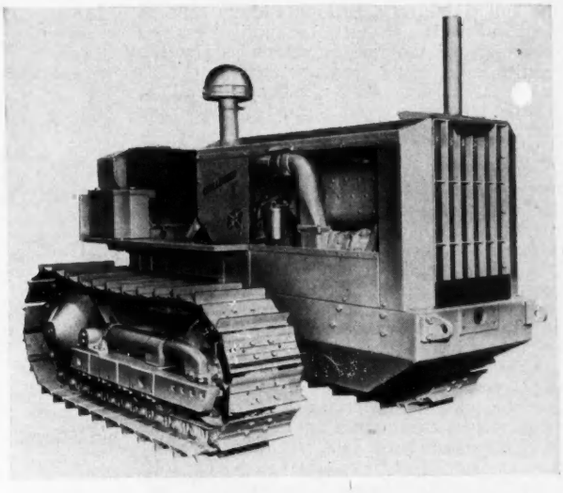


Fig. 2 Challenger 1, the smallest, developing 50 h.p.

FROM MARKET RESEARCH TO PRODUCTION

THE DEVELOPMENT OF "CHALLENGER" TRACTORS

Following the second World War, John Fowler and Company (Leeds), Limited, decided to produce a range of crawler tractors to meet the expanding world demand for these machines, particularly in the undeveloped countries of the sterling area. The firm had been associated with crawler tractors and tracked vehicles since the first World War (they built, in 1933, the first British machine to be fitted with a Diesel engine), but owing to British preoccupation with armament manufacture, American makers had become the principal world suppliers of commercial crawler tractors. The tractors now produced by Fowler's are known appropriately by the name "Challenger."

Market research indicated that a range of four sizes, from 50 to 150 brake horse-power, would meet world-wide requirements, and that provision would be necessary for mounted and towed equipment such as bulldozers, scrapers, etc. The four designs were developed concurrently, but the Challenger 3 of 95 brake horse-power was the first to go into production, since it was realised that this size would have the widest application. The first Challenger 3 was produced in December, 1950, and some 700 machines have since been put into service. It was followed early in 1952 by the Challenger 1, of 50 brake horse-power, and at the beginning of 1953 by the Challenger 4 of 150 brake horse-power. The Challenger 2 will be going into production at a later date.

While these machines were being introduced, production of the firm's Mark VF tractor was continued. It is a 40-brake horse-power crawler machine, based on the design of the "Field Marshall" wheeled tractor, a product of Marshall Sons and Company, Limited, the parent company of the Marshall Organisation.

The largest and smallest of the Challenger range are shown in Figs. 1 and 2.

HULL CONSTRUCTION

In general, the same design principles were followed throughout the range, emphasis being laid on simplicity, unit construction, ease of maintenance in the field, independently hinged track frames and provision for all stresses imposed by ancillary equipment to be taken by the hull and track frames, rather than by the transmission casings. Other points included the maintenance of a low centre of gravity and maximum interchangeability of parts between models. Of these, possibly the most important was the decision to avoid stressing the transmission casings, as this led to the use of a hull type of construction with its attendant robustness. In addition, the transmission assembly was simplified as the casings only had to withstand the stresses imposed by the drive.

The construction of the hull will be apparent from Fig. 4, which shows that used for the Challenger 3. The hull of the Challenger 4 is generally similar. In the illustration, the bevel box is shown in position, with the fuel tank immediately forward of it. These units help to stiffen the sides of the hull, which is formed from ¾-in. plates joined at the front by a substantial cross beam, the assembly being completed by bottom and front sealing plates to form a rigid punt-shaped structure. The fuel tank is set low down in the hull to assist in lowering the centre of gravity. The bevel box consists of an all-welded box-shape fabrication, with the gearbox flange-mounted to it, as shown in Fig. 5. The gearbox is an independent unit, complete with its controls, and can be removed for servicing without removing either the power unit or the rest of the transmission. There are six forward speeds. The first four speeds can be reversed instantaneously by means of a separate direction lever, each reverse speed being slightly higher than the corresponding forward ratio.

SUSPENSION

As previously mentioned, the track frames are hinged independently, i.e., they do not swing about the sprocket shaft as is normally the case. This is an important feature as it permits the removal of the final drive assemblies without disturbing the track frames. The construction of the track frames and the method of anchoring them to the hull are apparent from Fig. 7, which shows a complete frame assembly. At the rear, the two track frames are held at the correct distance apart by a circular cross-beam. This is secured to the hull at a point just in front of the final-drive assemblies (as shown in Fig. 6), the frames being free to pivot independently about the cross-member. A second cross-member is set at approximately the centres of the track frames and is also held to the hull in bushes. The ends of this cross-member, however, are cranked, with the cranks set at 180 deg. to each other and the free ends linked to the track frames. Thus when uneven ground causes the track at one side to rise, the tendency is for the other track to be correspondingly forced down,

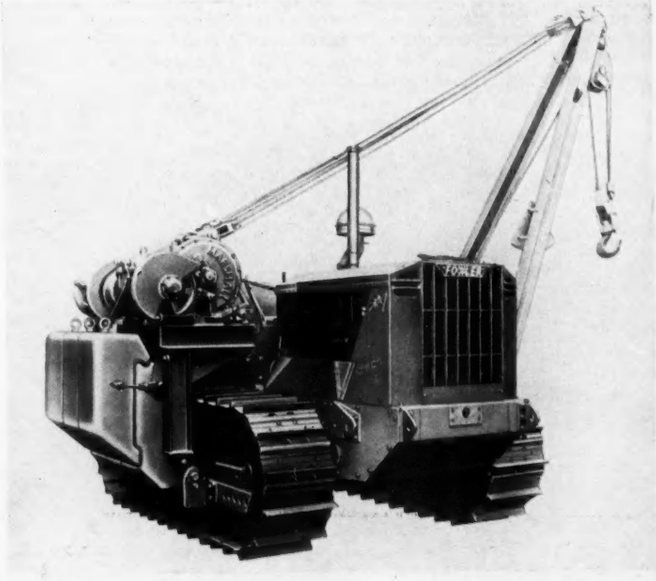


Fig. 3 Side-boom tractor for pipe-laying.

the hull taking up a position midway between the two levels. In fact, the uprightness, or otherwise, of the hull is determined by the relative levels of the tracks at their rear ends below the main cross-member. When the tractor is travelling it is thus eased gradually over every bump or hollow.

With this design the tracks are held parallel to each other at all times, regardless of the attitude of the tractor; it is virtually impossible for the tracks to "toe-in" or "toe-out" – major causes of track and track-roller wear. This type of design has substantial advantages not only in simplifying maintenance, but also as regards improved adhesion, in that the full weight of the tractor, including tracks, is available to resist the over-turning moment resulting from the driving torque and drawbar pull.

As previously indicated, this form of suspension permits the removal of the final-drive assemblies without disturbing the track frames – an important advantage when it is necessary to carry out repairs in the field. To remove a final-drive assembly it is only necessary to split and fold back the track, remove the sprocket and then unbolt the assembly from the side frame, the assembly being supported by wood packing during the final operation. A near-side final-drive assembly is shown in the course of removal in Fig. 6; the sprocket is shown in position, but normally it is removed for this purpose.

The track rollers, links, pins, bushes, idler wheels and sprockets are identical on the Challenger 3 and 4 models. Each track frame is carried on five track rollers (six in the case of the Challenger 4) which are of the centre-thrust bushed type. The two track carrier rollers installed above each frame (Fig. 7) are interchangeable with the bottom roller. The front idler wheels are mounted in cast-steel forks with slide brackets which move in guides fitted to the frames. Single-point adjustment is provided for track tensioning, and totally-enclosed spring recoil units are anchored directly to the rear track-frame pivot brackets. Pin and bush tracks are used and, to facilitate servicing, three master pins are fitted to each track. The track plates are made from rolled-steel sections specially toughened, with integral grousers, and the wearing surfaces of the track links, pins, bushes and rollers are induction hardened.

DIFFERENCES IN DESIGN

Although the basic principles of design and appearance of the three machines are similar there are, of course, differences between them. The Challenger 1, illustrated in Fig. 2, is fitted with a Marshall two-stroke two-cylinder Diesel engine developing 50 brake horse-power at 1,250 r.p.m. The Challenger 3 is powered either by a Meadows Diesel engine having a capacity of 633 cub. in., or by a Leyland Diesel engine with a capacity of 597 cub. in.

The Challenger 4 tractor (Fig. 1) closely resembles the Challenger 3 in appearance, but is fitted with a considerably more powerful engine – namely, the Meadows 6DJ970, a six-cylinder Diesel unit derated to provide 150 brake horse-power.

The principal characteristics and performance of the three sizes of machine are shown in the Table, the figures for the Mark VF being included for comparison.

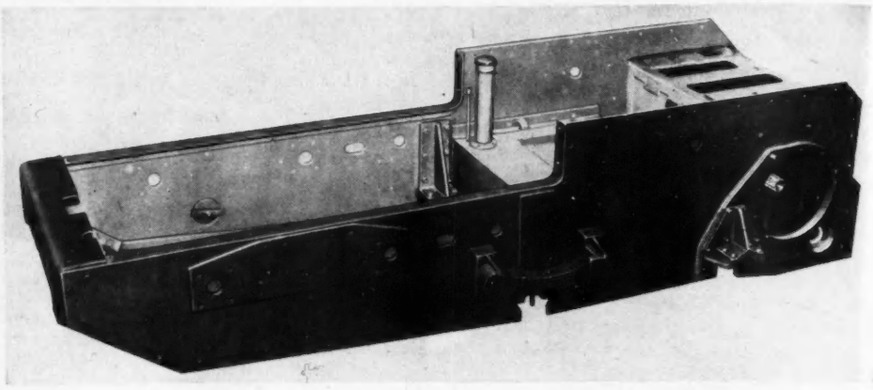


Fig. 4 By basing the design of the tractor on the hull frame shown here, the transmission casings are relieved of all stresses other than those due to the main drive; unit construction is facilitated and production and maintenance are simplified.

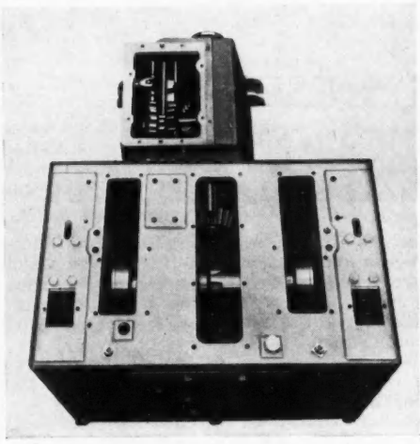


Fig. 5 The gearbox (at the top of the illustration) bolted to the bevel-box.

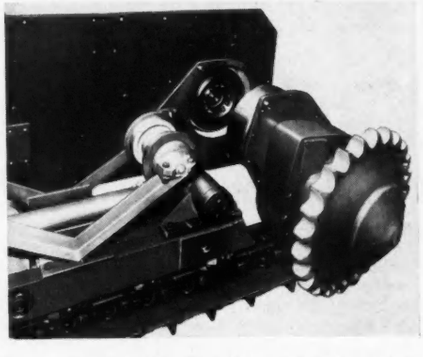


Fig. 6 A final-drive assembly, with its sprocket, removed from the side of the hull. This illustration shows one of the track frames in position, pivoted below and forward of the final drive.

PRODUCTION SHOPS

Although the existing premises of Messrs. John Fowler at Leeds were well suited to the production of crawler tractors, a number of alterations were introduced to facilitate increased output and improved quality control. The existing foundry, for example, was completely stripped, the floor concreted, and is now used for the mounting of ancillary equipment after tractors have been completed on the assembly line, and for packing and dispatch. Castings, both steel and iron, are now obtained from the mechanised foundry at Sprotborough, near Doncaster, another unit in the Marshall Organisation.

Other major changes carried out in the works included the replanning of the machine shop, and the installation of special-purpose machine tools; extension of the carburising capacity; installation of induction hardening equipment for the track components; and the laying down of the tractor assembly lines.

CARBURISING SHOP

To meet the need for increased carburising capacity, it was decided to instal a completely new gas-carburising plant. This type of plant was chosen because several of the components, such as gears, track parts, etc., were too bulky for carburising in boxes using solid agents. It was supplied by the Incandescent Heat Company, Limited, and is illustrated in Fig. 8. Designed to process approximately 130 tons of components a week, it consists of six vertical-cell gas carburising furnaces and three oil-quenching tanks. As will be seen from the illustration, the furnaces are arranged in two rows of three with the quenching tanks between them. At one end of the line of quenching tanks there is a washer for removing oil from the parts, and this is flanked on each side by the two tempering furnaces. These two furnaces and the washer can be seen in the foreground of Fig. 8. The neutral atmosphere for the furnaces is applied by two endothermic gas-producing plants.

Adjustable loading jigs are used to accommodate the work during processing, the jigs being designed so that they can be built up in several different ways to hold any type of component. The jigs are loaded into, and removed from, the

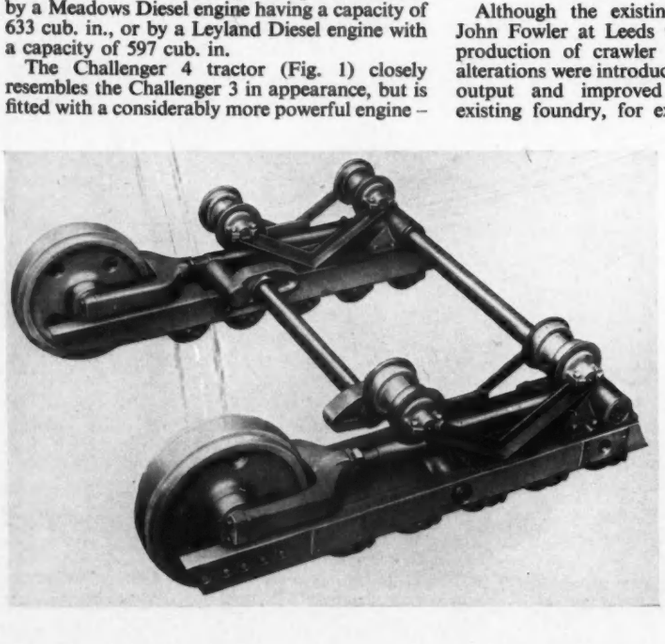


Fig. 7 The two track frames, with the idler wheels, load rollers and carrier rollers. The left-hand cross-member is cranked at both ends, where it is coupled to the track frames, in order that the tractor may accommodate itself to rough and undulating ground.

Fig. 8 The gas carburising shop at the John Fowler tractor works can handle 130 tons of components a week. In the centre foreground is an oil-removing washer ; on each side of it is a tempering furnace ; beyond them, on each side, are three gas carburising furnaces ; and between the carburising furnaces are three oil quenching tanks.

furnaces, etc., by a 30-cwt. Aabacas overhead traveller. The furnaces are of the Incandescent Heat Company's standard vertical-cell type. The work jigs are located by means of a nickel-chromium stool at the base of each furnace and are enclosed by a cylindrical work shield. A high-speed fan fitted with Nimonic blades is provided below each stool to promote turbulent circulation of gas within the furnace and thus ensure even carburising of the parts.

The furnaces are heated by town's gas burnt in air, both the gas and air being boosted by fans to a pressure of about 8 in. w.g. Combustion takes place in tubes round the furnace walls, and the temperature of each furnace is controlled by a Foster Potentiometric recording pyrometer which operates in conjunction with a Satchwell-Selas gas-and-air proportioning valve. To prevent the formation of scale on the work, an inert gas is fed to the furnaces at the rate of 60 cub. ft. per hour, the gas being obtained by cracking town's gas in the endothermic producers. A lithium-based fluid known as Lithanol is used as the carburising agent. It is injected into the furnaces by C.A.V. Diesel-engine injection pumps and injectors and is fed at a rate of approximately ¾ pint per hour. Each metering pump is provided with a micro-vernier adjustment, and by this means exceptionally accurate control is obtained. The results have, indeed, been very satisfactory regarding quality and quantity of material processed in this plant.

The induction hardening plant installed in the company's works is of their own design and construction. There are two motor-generator sets supplying current at 10,000 cycles per second, and the complete installation is designed so that it is fully automatic, the time sequences for heating and quenching being closely controlled.

TRACTOR ASSEMBLY

The methods used for building up the tractors are similar to those employed in modern motor-car plants, each model being assembled on a separate line. At present there are four lines, one for the Mark VF and three for the Challenger series, situated side by side as shown in Fig. 9.

The hull passes down tracks through a series of sub-assembly areas, the sub-assemblies being added to the machine as it progresses forward. At the first station, the two side plates which form the basis of the hull are held upright at their correct relative positions in a jig and the bevel box is bolted in position. The fuel tank and front support member, or cross-members, are also bolted in position at this stage, together with the bottom and front sealing plates.

At the same time as the hull is being erected, a corresponding track frame is assembled at a point just in front of the hull. The track frame is built up on an elevated portion of the assembly track and is assembled complete with bottom rollers so that, on completion, it can be rolled forward and downward by hand ready to receive the hull. The track frame and hull then proceed, forward as a unit through the various assembly stations, where the gearbox, final-drive units track recoil-spring assemblies, tracks, engine, etc., are added. Both the gearbox and the final drive assemblies are built up in a separate part of the assembly shop and are delivered to the side of the assembly track by overhead travellers. When completed, both these sub-assemblies are "run in" for three hours, for which purpose they are mounted on special jigs and driven by electric motors. After the gearbox has been added and the bevel wheel fitted in position, the whole assembly is driven by an electric motor for another period of two hours, and after the steering clutches and final-drive assemblies have been added to the hull, the complete transmission assembly is given a further run-in.

Assembly of the tractor is completed by installing the engine, controls, radiator, etc., after which the tractor is driven away for final tests; these include runs on a skid pan, during which the tractor is operated in each gear in turn. All engines are, of course, tested at the makers' works to ensure that the rated horse-power is developed, and further testing of the completed machines can be carried out to suit customers' requirements on a nearby test field. After completion of all tests, the tractors are driven to the equipment shop, where additional items are fitted, such as bulldozers and winches, the machines then being painted and prepared for delivery.

A particularly interesting item of ancillary equipment is the side-boom crane for pipe-laying, designed and manufactured by Marshall, Sons and Company, and illustrated in Fig. 3. This unit is built in two sizes to suit the Challenger 3 and Challenger 4, the maximum lift being approximately 18 tons at 4 ft. overhang with the Challenger 3, and 27 tons with the Challenger 4. These figures represent the maximum load at which the machine will begin to tip. On the British rating, two-thirds of tipping load, the figures are 12 tons and 18 tons, respectively.

PRINCIPAL DIMENSIONS, ETC.

Type	Length	Width	Height	Weight, lb.	Ground Pressure, lb. per sq. in.	Speeds, m.p.h.	Maximum sustained Pull, lb.
Mark VF ..	8 ft. 4½ in.	6 ft. 0 in.	7 ft. 0 in.	10,220	6·0	1st: 1·26 6th: 5·42	11,200 1,430
Challenger 1 ..	9 ft. 10 in.	6 ft. 0 in.	7 ft. 6 in.	11,750	6·09	1st: 1·68 6th: 7·20	10,000 1,150
„ 3 ..	13 ft. 11¼ in.	7 ft. 8 in.	9 ft. 1 in.	24,517	6·52	1st: 1·50 6th: 5·67	23,000 3,640
„ 4 ..	16 ft. 1½ in.	8 ft. 4 in.	9 ft. 1 in.	30,160	6·77	1st: 1·54 6th: 5·8	32,000 6,300

Fig. 9 Assembly line of Challenger 4 tractors on the left, and of Challenger 3 tractors on the right.

RADIOACTIVE ISOTOPES

THEIR PRODUCTION, PROPERTIES AND APPLICATIONS

The disposal of the fission residues of atomic piles has of recent years proved an increasingly serious problem, but, although no entirely satisfactory solution has been found, it has now become possible to convert these otherwise waste materials to profitable use on a comparatively large scale. To house equipment for investigating these problems, the premises of the Radiochemical Centre at Amersham, Buckinghamshire, have lately been extended; and in the new buildings are to be installed plants for the preparation of radioactive isotopes by two independent processes.

The annual supply of fission products is approximately equivalent to 20,000 tons of radium, the use of which element was formerly very much restricted because of its scarcity. It was especially in demand for medical purposes but has now been supplemented by the new materials, which are in relative abundance.

Radioactive isotopes have applications, not only to certain branches of medicine, but also to numerous industrial needs, and the provinces in which they are employed include those of electronics, weld analysis, thickness gauging and product tracing.

PRODUCT TRACING AND "LABELLED" COMPOUNDS

The path taken by a chemical compound during a process – or of its constituent elements if it is broken down – can be traced if certain of its atoms are radioactive. This condition can be obtained if radioactive isotopes are introduced into its composition when it is prepared. A radioactive isotope behaves chemically in exactly the same way as the normal isotope of the same element but its radioactive property enables it to be recognised by physical methods and so traced, whether it be combined with other elements or not. Hence, in any cycle of chemical reactions, the distribution of products at any stage in the process may be investigated by means of radioactivity checks. Chemical substances containing radioactive atoms are known as "labelled" compounds.

WELD AND CASTING ANALYSIS

Other radioactive substances produced at the Radiochemical Centre include gamma-ray sources, which are used in industrial radiography. The sources, which are contained in small cannisters, are employed, in a similar manner to X-ray equipment, to project the skeleton-shadow of an article under examination on to a photographic plate. Weld and casting analysis is among their most important applications and they are especially convenient for use in circumstances where inaccessibility excludes the employment of standard X-ray plant.

A small capsule of the isotope caesium-137 about the size of a pea can provide sufficient radiation for this purpose, and it is therefore immensely more compact and portable than a conventional X-ray generator, which requires in addition a high voltage for its operation, unlike the spontaneous and unaided action of the isotope. Other sources suitable for shadow-projection are cobalt-60 and radon adsorbed on a charcoal pellet, but caesium-137 remains active for the longest period, having a half-life of 33 years. It is also potentially more plentiful.

Alpha- and beta-ray appliances are generally made for industrial applications in the form of silver foils, plaques and wires. The radioactive material is firmly bonded within the metal so that it cannot be released accidentally. The sources are also resistant to moderate abrasion or chemical corrosion, and may be riveted or soldered to other apparatus.

THICKNESS GAUGES

They may be incorporated in thickness gauges, static eliminators, position indicators and as initiators in gas discharge tubes. They are also frequently used in laboratories as reference standards for measuring equipment. As the active components in thickness gauges, they are embodied in some cigarette-making machines to check the fineness of tobacco strands and sources made for this purpose are normally produced as foils approximately 0·15 mm. in thickness. Most commonly employed in beta-radiation appliances is strontium-90 which has a half-life of nearly 20 years. A strontium-90 foil such as that use for thickness gauges is shown being rolled in Fig. 3.

Strontium-90 is a source of high-energy electrons and by measuring the proportion of these rays that pass through a given sheet of material its thickness can be estimated. Not only does a gauge constructed on this principle avoid contact with the article under inspection, but with its aid thickness measurements of such materials as paper, cardboard, linoleum and thin metal foils can be made continuously as they are produced.

The increasing number of industrial, medical, agricultural and laboratory applications of radioactive isotopes and labelled compounds has created a great demand for these substances and, to cope with it, the Radiochemical Centre has not only expanded its premises but also developed methods of producing isotopes safely in large quantities. Hitherto, they had been obtained by laboratory methods on a small scale with some direct manipulation; now, for several of the more important isotopes, separate chemical plants have been built.

LARGE-SCALE PRODUCTION

These plants are completely screened and remotely operated and have been installed in buildings designed to accommodate them. The buildings, in accordance with the Centre's requirements, were planned and erected by architects and engineers of the Ministry of Works. Improved facilities for dispensing, packing and dispatching have been included.

Four of the eight buildings projected have so far been built and each is used for a group of similar processes. In one the separation of fission products is carried out; in another, radioactive iodine, phosphorus and other short-lived isotopes are produced. The dispensary for radioactive solutions, the interior of which is illustrated in Fig. 1, occupies a third and the fourth is for biological processes.

Each building consists of a single room of 900 sq. ft. floor area entirely clear of permanent fittings. The four buildings are set well apart to reduce the radiation field between them and to allow access for heavy vehicles carrying supplies of radioactive raw materials. The necessary services to ensure efficiency and safety have been provided, including a high-speed circulation and air-preheating ventilation system and special drainage for radioactive effluent designed to serve six production units in each room.

Installation of chemical production plants has been in progress for about six months and is nearly half completed with five units in operation. The design of the plants is unusual in that they are constructed from interlocking bricks and can be dismantled rapidly without affecting the structure of the buildings. Modifications may thus be easily introduced whenever required. The bricks, which are of lead or concrete, form screening walls, and all equipment which may become radioactive is contained in sealed compartments. Handling rods with mechanically operated grips, and other methods of remote control eliminate any direct manipulation.

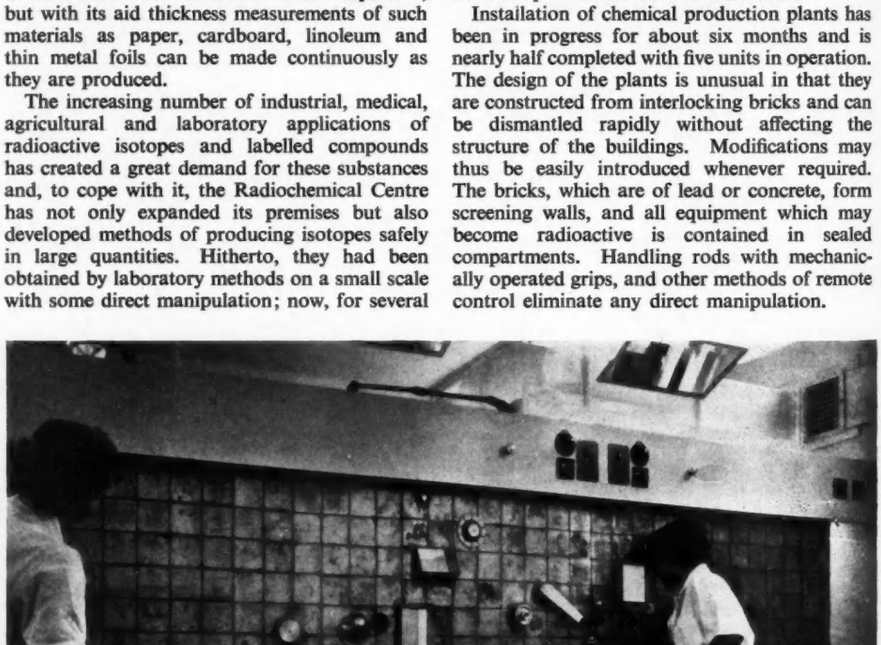


Fig. 1 Remote manipulation and 4-in. lead screens enable solutions of gamma-radiation sources to be bottled with safety in this dispensary.

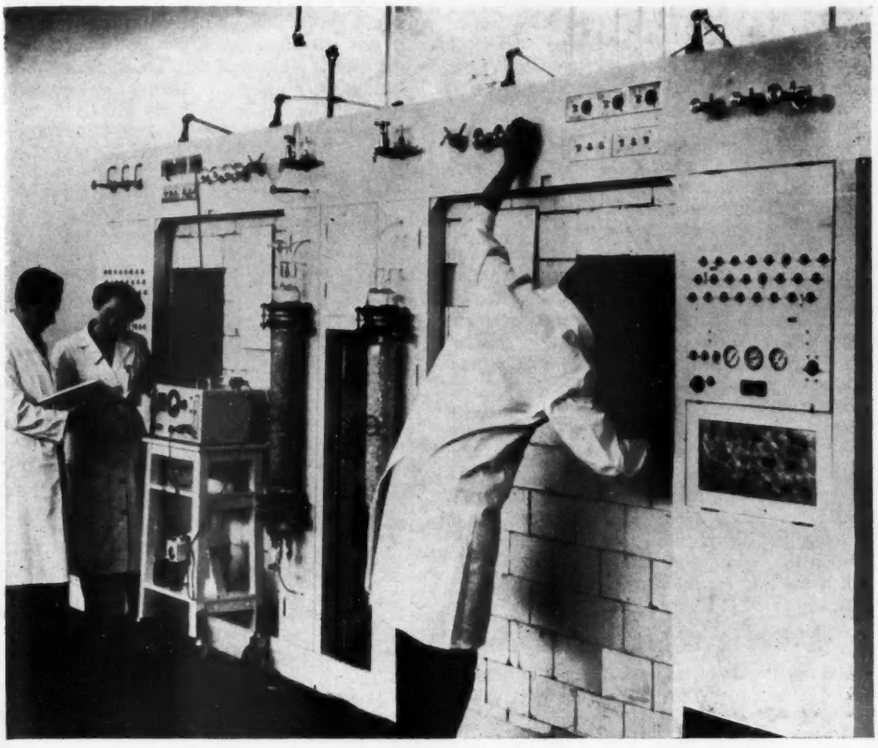


Fig. 2 The separation of strontium-90 and caesium-137 from waste fission products is carried out in this laboratory. Concrete walls 2 ft. thick protect the operators.

The interior of a laboratory at the Centre is shown in Fig. 2, above, and the chemical separation unit illustrated comprises two cells, each operated independently. The operators are protected from radiation by a wall, 2 ft. in thickness, made of concrete bricks. In the dispensary – which at present only deals with solutions of gamma-radiation sources – the screening consists of interlocking lead bricks and the thickness of the wall is there 4 in. with 6-in. lead-glass windows. The dispensing operations can also be observed by means of the mirrors placed above the open chamber.

There are two standard methods of obtaining radioactive isotopes suitable for the applications already mentioned. One process entails separation of the substances required from waste solutions of fission products; these are received, after removal of plutonium and uranium, from the production factories in the north of England. The other involves the irradiation of a parent element or target material.

ISOTOPES BY IRRADIATION

Carbon-14, which is the most versatile single isotope, is, for example, made by irradiating nitrogen with neutrons. The target material, which, in the form of aluminium nitride, is prepared at Amersham in a very pure condition, is sealed in aluminium containers and sent to the production piles at Windscale to be irradiated for about a year. The active material is then returned to the Radiochemical Centre and carbon-14 is extracted from it. Carbon-14 provides the basis for numerous radioactive organic compounds synthesised at Amersham.

The routine production of about a dozen other "separated isotopes" is carried out at the Centre, usually by extraction from materials irradiated in B.E.P.O. at Harwell, but occasionally also by cyclotron irradiation. Fortunately the two isotopes in greatest demand for medical purposes, iodine-131 and phosphorus-32, can be used in the simple chemical form in which they are first extracted; but more frequently, and increasingly so, isotopes are required as compounds, and the variety now available compares in range with the normal laboratory reagents.

ISOTOPES FROM FISSION PRODUCTS

Fission residues, which are the second source of radioactive isotopes, are brought to the laboratories for separation in the form of the concentrated solutions from which the uranium and plutonium have to be removed. Twenty gallons of such a solution are transported in a cast-steel container about 8-in. thick and weighing 8 tons.

Strontium-90 and caesium-137 are two isotopes obtained by separation from other fission products and these will be produced in quantities of about 100 curies each year by the two units built for that purpose. Approximately 200 isotopes have been identified in fission residues but so far only a small proportion of them have been extracted and put to use.

APPLICATIONS TO PLASTICS AND FOOD

Consequently the search for new applications continues; prospective developments include: self-luminous plastics, miniature electric batteries, the elimination of static electricity and electron emitters in radio valves and television tubes. Another field of uses at present under investigation is the initiation of chemical processes.

When radiation is absorbed in matter, heat energy is released and the temperature of the target material raised. This energy is distributed in intense local concentrations such that "hot spots" are produced, and the effect may be limited to small groups of molecules or even single atoms. The disturbances caused, although isolated, are very severe and atoms may be displaced to new positions, molecules disintegrated and chemical reactions started. Since the effects are local, no significant rise in temperature of the whole irradiated material occurs and chemical changes, normally only possible at high temperatures and pressures, may be induced at room temperature.

In general, the initiation of processes by radiation is inefficient when compared with ordinary methods and even large quantities of fission products may be insufficient for processes carried out on an industrial scale. Nevertheless there is one form of reaction in which radiation has proved efficient; this is polymerisation, which is employed in the production of plastics. It is uncertain whether radiation processes would be more economic than the existing ones, but, since the fission products are for disposal, the raw materials would not be costly.

Another application of fission products that has been suggested is concerned with food preservation. Although a considerable quantity of radiation is required to kill any appreciable concentration of bacteria, it is possible that sterilisation by radiation would have advantages over such methods as cooking and the addition of chemical preservatives, in that these tend to destroy the freshness and flavour of foods. Radiation, however, might also have unpleasant or even harmful effects.

The investigation of this and other speculative applications of the copious and growing stock of fission products will, in the next few years, call for considerable large-scale experiment, and, if fission residues are to be used in quantity safely and to good purpose, numerous technical and economic problems have yet to be solved.

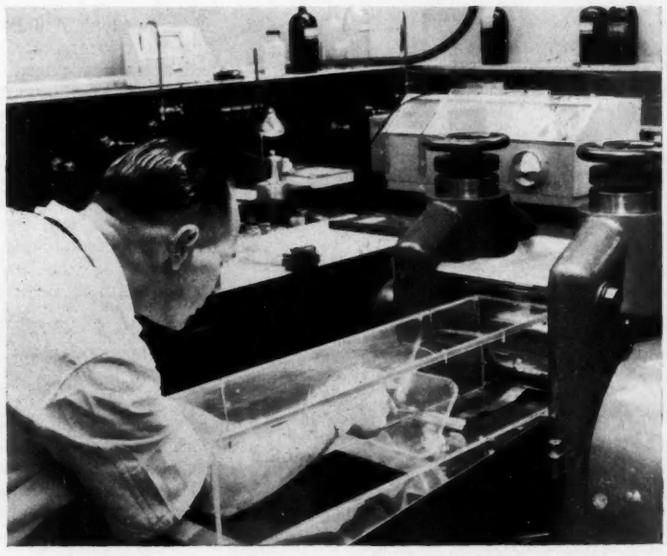


Fig. 3 Strontium-90 is used in the form of foils, plaques and wires and its applications include thickness gauging. The method of rolling foil is shown here; the operator is protected by plastic screening.

ULTRASONIC DRILLING MACHINE FOR HARD MATERIALS

DRILLING IRREGULAR SHAPES AND CURVED HOLES

It is now well known that circular holes and apertures of any other shape can be formed in hard and brittle substances by means of a rapidly reciprocating tool of soft material, such as brass or mild steel, fed with an abrasive slurry. A machine of this type suitable for bench mounting and capable of machining holes ranging from 0·006 in. to ½ in. across and up to ½ in. in depth, has recently been made available for industrial use by Mullard, Limited, Century House, Shaftesbury-avenue, London, W.C.2, who are also carrying out trials on a larger machine. The latter can be used for forming holes up to 2 in. across to a maximum depth of 2 in. and both can be used, with suitable tools, for machining operations such as cutting, shaping, hobbing, grinding, polishing, etc.

50-WATT MACHINE

The smaller machine, which is rated at 50 watts, is generally similar to a normal light bench-type power drill and can be operated from alternating-current mains at from 110 to 250 volts. It consists of two main parts: a drill head mounted on a bench stand, as shown in the accompanying illustration, Fig. 1, and an ultrasonic power unit connected to the drill head by a single four-core cable. The drill head, it will be seen, is mounted on a lever-operated counterbalanced fitting which slides on a vertical pillar. The only controls required are one for tuning and a simple on/off switch. Enclosed in the drill head is a transducer of the magnetostriction type which gives the reciprocating motion to the tool. The transducer consists of a stack of nickel laminations clamped at its nodal point and energised by a coil to which current is supplied at a nominal frequency of 20 kilocycles per second from the power unit. A stainless-steel plate is brazed on to the lower end of the transducer and, into a tapped hole in this plate, brass stubs which carry the tools are screwed. Three of these stubs, which function as mechanical transformers, are provided, their cross-sectional area being specially designed so that the amplitude of the vibrations applied to the upper and larger end is increased at the lower and smaller end due to a resonance effect. The amplitude of the vibration at the face of the transducer is of the order of 0·0005 in. and the three stubs increase this amplitude in the ratios of 2 to 1, 3 to 1 and 6 to 1, respectively. The amplitudes at the tips of the stubs, into which the tools are screwed, are therefore about 0·001 in., 0·0015 in. and 0·003 in., respectively. One of the stubs is shown in position in the drill head in Fig. 1, and two can be seen to the left of a metal tray for the slurry in the same illustration.

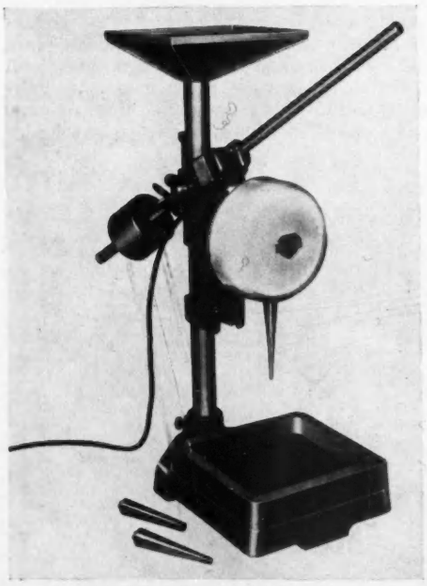


Fig. 1 Holes of irregular shapes can be drilled in hard materials, such as tungsten carbide, by this 50-watt ultrasonic drill and bench mounting. Dimensional accuracy to within 0·0005 in. can be achieved.

FUNCTION OF POLARISING MAGNET

The upper part of the transducer is located in the air gap of a polarising electromagnet which is energised by direct current supplied from a rectifier in the power unit. The object of the polarising magnet is to maintain a steady flux in the transducer close to its magnetic saturation point. The high-frequency flux variations in the transducer due to its energising coil are thus superimposed on this steady flux, the result being to increase the magnetostriction effect and greatly to reduce eddy currents.

The power unit has an ultrasonic output of 50 watts at a nominal frequency of 20 kilocycles, the circuit comprising a free-running symmetrical multi-vibrator which may be tuned for frequencies ranging from 16 to 24 kilocycles. The output of the multi-vibrator is supplied to a single amplifying stage which drives two output pentodes in parallel; connection to the transducer is made through an output matching transformer. The rectifier which supplies low-voltage direct current to the windings of the polarising magnet is of the full-wave type.

250-WATT MACHINE

The 250-watt machine, illustrated in Fig. 2, is suitable for mounting either on existing machine tools, such as vertical millers, jig grinders, etc., or on a standard pillar-type drill stand. The drill head incorporates its own vertical slides and a pneumatic feed which permits accurate control of cutting. A built-in dial gauge indicates the depth of penetration. Provision is also made for the automatic periodic retraction of the tool so that deep holes can be flushed out with fresh slurry at intervals. For automatic operation a slurry pump must be provided and the flexible tube through which the slurry is delivered to the tool can be seen in Fig. 2. If the machine is intended for manual operation the slurry can, of course, be fed by hand.

EFFECT OF SLURRY ON FINISH

The slurry consists of a suspension of silicon carbide or boron carbide in water, according to the material being machined. Obviously, the surface finish and dimensional accuracy of the work depends upon the size of the abrasive particles in the slurry. As in normal machining, it is possible to use a roughing cut followed by a finishing cut, analogous to reaming, in order to obtain high accuracy. For instance, the dimensional accuracy obtained in the roughing cut, using a 120-mesh abrasive, is usually to within 0·002 in. or 0·003 in., while with a finishing cut using a 1,000-mesh abrasive dimensional accuracy to within 0·0005 in. can be achieved. Some idea of the speed of working with different materials may be obtained from the fact that with the 50-watt machine a ¼-in. hollow square tool will penetrate soda glass to a depth of 1 mm. in 30 seconds, while the same tool would take 10 minutes to obtain the same penetration in tungsten carbide.

TOOLS REQUIRED

The tools employed are generally made by the user and are screwed into the end of the stub. With a little ingenuity tools can be made for operations which it would be extremely difficult or impossible to carry out by normal methods of machining. For instance, by using as a tool a wire bent into the arc of a circle, curved holes can be drilled. In any case the shape of the cut closely follows that of the tool and it should be noted that during the machining operation the workpiece is not subjected to any stress and to very little heating, so that troubles due to distortion and deformation are avoided.

* * *

INFORMATION WANTED ON ROCKWELL SCALES

A British Standards Institution Committee is at present engaged in the revision of B.S. 891 : 1940, Direct Reading Hardness Testing (Rockwell principle). In order that present-day practice may be recognised in this revision the Committee would be grateful for any information on the extent to which Rockwell scales other than A, B or C, are now in use. Letters should bear the reference MEE/37/9/1 and be sent direct to the B.S.I., 2 Park-street, London, W.1.

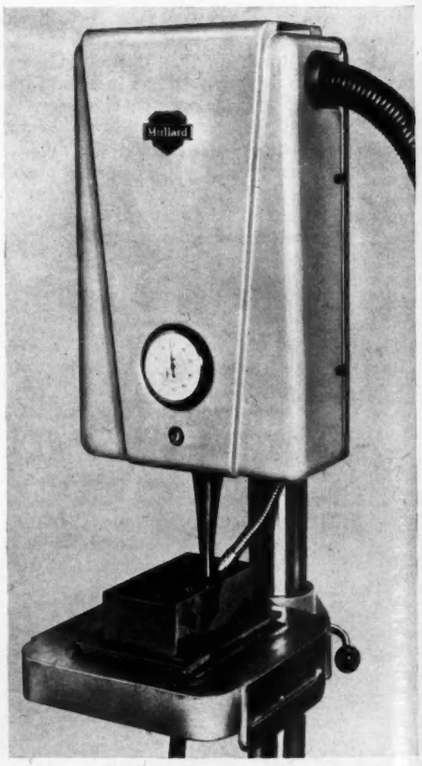


Fig. 2 250-watt ultrasonic drill suitable for mounting on existing machine tools.

ENGINEERING EXHIBITS AT THE B.I.F.

The machines, etc., illustrated on this page, which are being exhibited in the Engineering and Hardware Section of the British Industries Fair, are briefly described on the two following pages.

Fig. 1 The ferrous material collected in this permanent-magnet floor sweeper is readily discharged by depressing the push handle. Electromagnets, Ltd.

Fig. 2 Centrifugal dryer for the rapid drying of small articles. W. Canning & Co., Ltd.

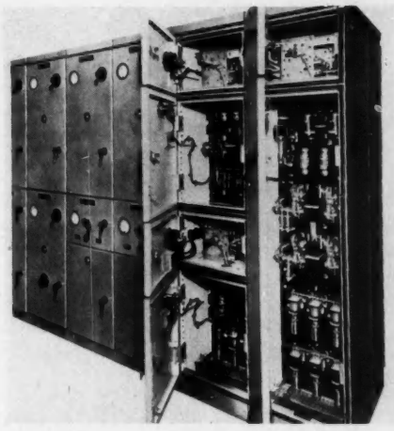


Fig. 3 440-volt group starter board and isolating switches. General Electric Co., Ltd.

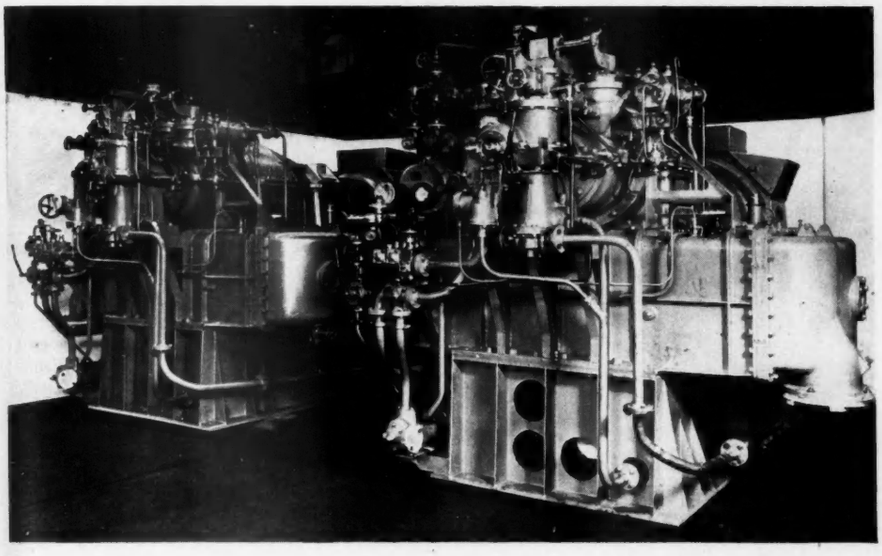


Fig. 4 550-kW marine auxiliary geared turbo-alternator sets. General Electric Co., Ltd.

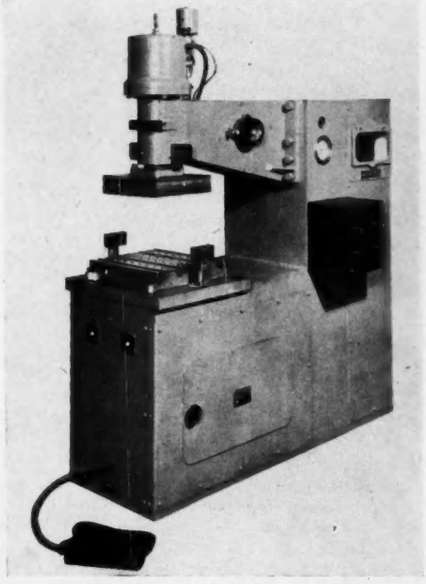


Fig. 5 Multiple-projection and cross-wire machine for simultaneously welding a large number of points in wire mesh. Sciaky Electric Welding Machines, Ltd.

Fig. 6 Fabric-type filter with automatic dust shaker. The shaking cycle for clearing the filter is fully automatic. Dallow Lambert & Co., Ltd.

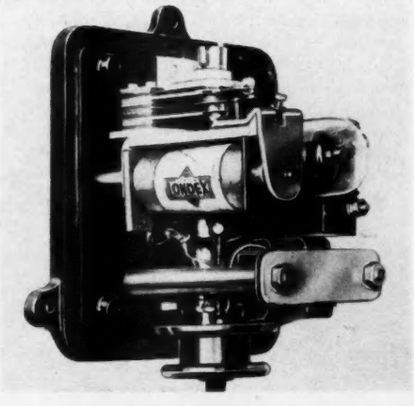


Fig. 7 Industrial electronic relay. Londex Ltd.

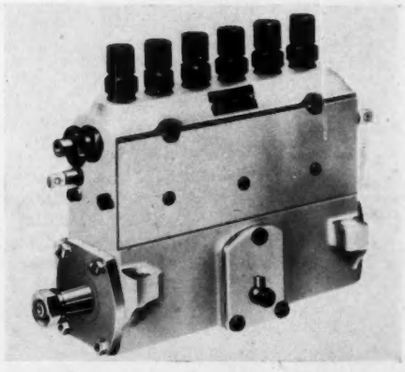


Fig. 8 Fuel injection pump, suitable for a pneumatic or mechanical governor. C.A.V. Ltd.

ENGINEERING EXHIBITS AT THE B.I.F.

THE Engineering and Hardware Section of the British Industries Fair, which closes at Castle Bromwich, Birmingham, on May 14, presents an exceptionally wide range of materials, plant and equipment. Descriptions of the exhibits illustrated on the previous page are here preceded by brief accounts of some other exhibits, including a system of continuous fenestration, a self-cleaning permanent magnet for removing tramp iron from free-flowing material, a press brake, bending rolls, materials for electrical insulation and resistance to chemical attack, and a lifting magnet with fine control.

ADAPTABLE GLAZING SYSTEM

The exhibits of Henry Hope and Sons, Limited, Smethwick, Birmingham, include examples of their steel window frames, and various types of glazing. In the latter category is a new product, the " Windogrid " system of continuous fenestration.

It consists basically of a skeleton of galvanised steel vertical members or mullions, running from floor to floor, where they are bolted to the steelwork or concrete of the main structure, and connected together horizontally by galvanised steel transoms. The steel members are then capped with extruded aluminium sections of special design, which accommodate the glass. The vertical members can be spaced at any required module, and the transoms can be at floor level or any other convenient point. Standard rolled bars, of a size to suit the span from floor to floor and between the verticals, are used for the steel skeleton. Wind pressure is transmitted directly to the floors by the steel mullions and transoms, and light, non-load-carrying panels of solid material can be used instead of glass at any point. Glass panes or solid panels of any size can be used by arranging the spacing accordingly, and the sizes can be kept small if desired by introducing additional glazing bars. The system is adaptable to any number of floors and any length of building, and all types of ventilator and opening casement can be fitted.

SELF-CLEANING PERMANENT MAGNET

Two new types of self-cleaning permanent magnet are included in the exhibits of Rapid Magnetic Machines, Limited, Lombard-street, Birmingham, 12. Both are for the extraction of tramp-iron from any free-flowing material and are intended for installation in a chute. The " Ejecta " magnet is hinged to the underside of the chute, and retained in its working position by two wing-nuts. When these nuts are removed, the magnet can be swung through an arc to break the magnetic field, and so allow the ferrous material to fall clear into a suitable receptacle. The magnet is then returned to its working position, and locked by means of the wing-nuts. For situations where cleaning at frequent intervals is necessary, and the operation must be as rapid as possible, the " Rotopole " magnet is used. This operates on a similar principle to that already described, but the magnet is swung clear by the operation of a single hand-lever. The trapped material falls away in the same manner, and the magnet is then returned to its working position and locked by the same hand-lever. Both these magnets are of the permanent type, but several examples of electromagnets are also shown. These include an electromagnetic separator for feebly-magnetic ores, which can give up to six products, according to the magnetic properties of the material passing over the belt.

PRESS-BRAKE AND BENDING ROLLS

Two machines, a 60-ton press-brake and a four-roll initial pinch plate-bending machine, are shown by the Bronx Engineering Company, Limited, Lye, Stourbridge, Worcestershire. The press-brake, which is of fabricated steel construction, is capable of bending mild-steel plate 8 ft. wide by 10 s.w.g., and 10 ft. wide by 12 s.w.g. It has a width between columns of 8 ft. 4 in. and is 10 ft. long over the beams. The main drive is from a 6-h.p. slip-ring motor, driving through machine-cut double-reduction gears, and giving a maximum speed of 30 strokes per minute, the stroke being 3 in. The top beam is adjusted by a 2-h.p. motor, which is controlled by push-buttons. Limit switches are provided to prevent over-run of the beam at both limits of its travel.

The plate-bending machine has positively-driven top and bottom rolls, which are each 6½ in. diameter, and idle side rolls of 5¾ in. diameter. The rolls are carried in phosphor-bronze bearings in fabricated steel housings, and the bottom roll is adjustable by means of a hand-wheel at the main control position. The side rolls are independently adjustable, and are provided with worm-gear drive and two 3-h.p. motors, controlled by push-buttons. Both side rolls and the bottom centre roll can be set out of line for rolling conical work. A swinging end bearing is provided at the outer end of the top roll, to enable closed circular work to be removed after rolling. A ball-end and jack support are provided at the inner end of the top roll, to support the weight when the swinging bearing is removed. The main drive is by means of a 7½-h.p. slip-ring motor running at 920 r.p.m., and coupled to the rolls through machine-cut double-helical gears. The gearbox is of cast iron, totally enclosed, and the gears run in oil. An electromagnetic brake is incorporated in the main drive, to bring the rolls to rest quickly when the power is cut off by the operator. The drive motor is equipped with a tramway-type controller.

NEW MATERIALS FOR INSULATION AND CHEMICAL RESISTANCE

Included in the range of materials exhibited by Permali, Limited, Bristol-road, Gloucester, are two new grades of Permali. One is for high-voltage electrical insulation, and has been specially developed for use in the tropics and elsewhere under conditions of high humidity. It has the same mechanical and dielectric strength as standard-grade Permali, but with substantially improved resistance to moisture. The material is suitable for a variety of electrical purposes, and the samples shown include air circuit-breaker drive-rods and mounting bases, air-insulated bus-bar spreader-plates and supports, and air-blast switchgear isolating drive-rods.

The second of the new materials is a non-electrical grade, which has a remarkably high resistance to most chemicals in industrial concentrations, particularly in the form of liquids and gases. It is suitable for fabricating into chemically-resistant structures and components. Examples of this material are shown in a water de-mineralising unit made by the Permutit Company, Limited, and a portable prospecting unit for locating uranium, produced by Ericsson Telephones, Limited. The latter is completely housed in a Permali case, and has been designed for tropical use. A fume-exhaust hood, which will resist attack by acidic and alkaline moisture-laden gases, is shown in cross-section to a scale of one-third full size. Numerous examples of the standard grades of Permali are shown; these include gears, press tools and textile accessories.

FINE CONTROL ON LIFTING MAGNET

The principal exhibit on the stand of Electromagnets, Limited, Boxmag Works, Bond-street, Birmingham, 19, is a new lifting magnet which can be controlled by the crane operator to vary the amount of material lifted or deposited. The magnet itself, which is made in various sizes, is of orthodox pattern, but is equipped with a special generating set and a single hand-lever control which enables the current to be varied, so increasing or decreasing the lifting power as required. The control lever has two marked positions, representing full lifting power and zero power respectively, and the power is infinitely variable between the two extremes. By moving the lever against a spring stop, extra lifting power can be exerted for short periods if necessary. The control lever is mounted in a small control box, which can be installed in the crane cab, or in any other convenient position.

PERMANENT-MAGNET FLOOR SWEEPER

Electromagnets, Limited, are also showing a new permanent-magnet floor sweeper, of the discharge type, which has a ground clearance of 2 in. To discharge the ferrous material collected, the push-handle is depressed. This breaks the magnetic field, and allows the trapped material to fall away on to the floor, whence it can be collected for disposal. The sweeper is illustrated in Fig. 1, on page 633.

ELECTROPLATING EQUIPMENT

W. Canning and Company, Limited, Great Hampton-street, Birmingham, 18, are showing several examples of their equipment for the electroplating and polishing trades. The largest exhibit, occupying the whole of one stand, is an automatic plating plant 35 ft. long, which only requires the services of a single operator. Articles to be plated are loaded on to carriers suspended from an overhead conveyor, and it is only necessary for the operator to place the articles in position and remove them after plating. Transfer from one tank to another, and immersion in the liquid, are fully automatic, the movement being partly electric and partly hydraulic. The tanks are heated by steam or electricity as required, and the exhaust ducting can be overhead or underground, whichever is most convenient. The machine is complete with ancillary equipment such as rectifiers, transformer, voltage regulator, filter and air pump, and is controlled from a cabinet at the loading and unloading position. The principle is adaptable to multiple processes, and a single installation combining copper, nickel and chromium plating can be supplied.

The machinery exhibited also includes several types of plating barrel, a finishing barrel for de-burring, scouring or burnishing small components in bulk, and centrifugal lacquering machines. A centrifugal dryer, for the rapid drying of small articles after plating, dipping or burnishing, is also shown (and is illustrated in Fig. 2), together with centreless and other types of polishing machine.

MARINE TURBO-ALTERNATOR SET

The stand of the General Electric Company, Limited, Kingsway, London, W.C.2, at Castle

Bromwich, is this year being principally devoted to marine engineering equipment. The application of auxiliary electric power on board ship is represented by the 550-kW geared turbo-alternator set illustrated in Fig. 4. This set, which was built at the Fraser and Chalmers Engineering Works, Erith, is similar to a number which are being supplied to Shell Tankers, Limited.

The turbine is a multi-stage impulse machine and is designed to run at 6,500 r.p.m. when supplied with steam at a pressure of 485 lb. per square inch and a temperature of 790 deg. F. It is coupled through reduction gearing to a drip-proof alternator which runs at 1,200 r.p.m. and generates three-phase current at 440 volts, 60 cycles. The main exciter is directly coupled to the alternator through a solid half coupling, while the pilot exciter is driven by V-ropes from an outboard grooved pulley.

The condenser, which is mounted on the base-plate underneath the turbine, has a cooling surface of 1,100 sq. ft. and is designed to maintain a vacuum of 28·5 in. when supplied with 1,250 gallons of water per minute at a temperature of 75 deg. F.

The set, which is capable of operating in sub-tropical conditions, the alternator having an overall rating of 25 per cent. for two-hour periods, is being shown with one condenser door removed so that the tubes can be inspected. The turbine rotor has also been withdrawn so that the construction and assembly of the blades and wheels can be seen.

ALTERNATING-CURRENT MARINE SWITCHBOARD

The control of such a set might well be effected from a cubicle-type switchboard which is also being exhibited. This has been designed without supporting frame-work and the unit parts enable cubicles up to 6 ft. 6 in. high to be assembled in standard widths from 1 ft. 6 in. to 3 ft. 6 in. and to be used individually or joined together to form one switchboard. Such cubicles can be employed to accommodate manually or electrically operated circuit-breakers, fuse-switches, contactors, isolators and instruments. The isolators are designed so that sudden current surges increase the contact pressure. The switchgear is mounted on insulated panels which are carried on an internal skeleton frame, and all parts which might normally require attention are accessible from the front, interlocks being provided so that isolation must occur before the door can be opened. The circuit-breakers are of the air-break type with arcing contacts of heavy-duty alloy.

440-VOLT GROUP STARTER BOARD

A G.E.C. group starter board exhibited (Fig. 3) is also of cubicle construction. Each starter is in its own cubicle with its isolating switch, the latter being interlocked with the door. The starters are equipped with overload relays which are designed to eliminate the risk of premature tripping and have a maximum operating time of 40 seconds at ten times full load.

A number of direct and alternating current motors are also being shown, the largest being a 178-h.p. 440-volt three-phase horizontal-spindle machine of the type used for driving boiler feed pumps.

The fans exhibited by Woods of Colchester, Limited, on this stand include one of the retractable axial type. This is carried on hinges in a main casing which is flanged at each end for fixing. The fan can be swung out for servicing without disturbing the electrical connections.

CROSS-WIRE WELDING MACHINE

The principal exhibit on the stand of Sciaky Electric Welding Machines, Limited, Farnham-road, Slough, Buckinghamshire, is the multiple projection and cross-wire welding machine, illustrated in Fig. 5. This machine has been designed so that a large number of welds can be completed simultaneously in wire mesh with a very low electrical loading. The electrical efficiency is high owing to the arrangement of the transformer and the T-slot platen. A further special feature is the automatic continuous feed. The wire mesh can be welded either in the square or in a series of lines. During the latter operation each line of cross wire can be fed into position continuously so as to form long lengths of mesh. The speed of automatic operation is about 60 feed-in movements per minute. The welding current is adjusted by phase shift so that the heat is infinitely variable. The pneumatic head cylinder can develop a pressure up to 4,000 lb. and the head itself can be retracted to give clearance for loading and unloading.

SEAM WELDER

Another machine shown by Sciaky Electric Welding Machines, Limited, is a motor-driven pneumatically-operated seam welder. It has a nominal rating of 75 kVA and is provided with arms which permit a working throat depth of 26 in. It has a welding capacity up to No. 16 by No. 16 s.w.g. in both mild and stainless steel, the welding speed being infinitely variable between 3 ft. and 12 ft. per min. Two bottom electrode inserts are provided, one for longitudinal and one for circumferential seams. The top electrode assembly can be swung round and fixed in position to suit the particular type of seam. The machine is fully automatic and the weld can be controlled either by a modulator or Ignitron which incorporates phase-shift heat control.

AUTOMATIC SHAKER FOR DUST COLLECTORS

Included in the range of industrial dust-control equipment exhibited by Dallow Lambert and Company, Limited, Spalding-street, Leicester, is a new " Auto-Shaker," for clearing the filters of dust collecting units. The device, which is fitted to one of the manufacturers' " Dust-master " units, as shown in Fig. 6, consists of a slow-speed geared motor and shaker, with the necessary electrical control gear, which is interlocked with the fan motor. When the fan is switched off, a delay mechanism comes into operation to allow the fan to stop, and thus to ensure that no air is passing through the filter. The shaker mechanism then starts automatically and runs for a set period under the control of a time switch. The length of the shaking period can be adjusted, by setting the time switch, to suit the particular application when the unit is installed, or to adapt it for different conditions. When the shaking cycle has been completed, the shaker motor stops, and the mechanism resets itself automatically. An electrical interlock prevents the fan motor from being started while the shaker is in operation, and for a short period afterwards. The mechanism can also be interlocked electrically with the machine being served by the dust collecting unit. In this case the machine, fan and shaker controls are all operated from one push-button station on the machine.

INDUSTRIAL ELECTRONIC RELAY

An attractive display of the automatic electric control apparatus manufactured by them, which comprises relays, timers, level controls, flow indicators, pressure and vacuum switches, photo-electric controls, automatic power-factor regulators and flashing beacons, has been arranged by Londex Limited, 207 Anerley-road, London, S.E.20, and includes the industrial electronic relay illustrated in Fig. 7. This relay consists of a small transformer, which acts as an isolator from the mains, a cold cathode valve and the relay proper, which is fitted with single-pole change-over output contacts with a switching capacity of 2 amperes at 250-volts alternating current. Connection is made to a standard single-phase supply and to the output circuit through a six-pin plug and socket, while the trigger circuit, owing to its high impedance, is connected by the coaxial plug and sockets.

As regards operation when the " trigger " circuit is completed, the cold cathode valve strikes and energises the relay, which is connected in its anode circuit. When the " trigger " circuit is broken the valve is extinguished and the relay is de-energised. The relay is so sensitive that it will strike even when the " trigger" circuit is connected through an external circuit of 2 megohms. Under such conditions the current is only about 0·03 milliamperes, but the circuit is so designed that even when it is completely shorted the maximum current does not exceed 0·1 milliampere. Damage to the contacts by arcing or burning is therefore unlikely.

Such an apparatus can be used in conjunction with a dial instrument fitted with contacts, to close an alarm circuit when an emergency occurs or to increase the switching capacity of mercury-in-glass contact thermometers by arranging for the " trigger " circuit to be completed when the mercury reaches a sealed-in contact.

FUEL-INJECTION PUMP

The exhibits on the stand of C.A.V. Limited, Acton, London, W.3, include a number of types of fuel injection pumps and examples of electrical equipment for commercial and passenger vehicles, as well as for stationary, agricultural and marine engines.

An addition to the enclosed camshaft range of pumps is the AA fuel injection pump illustrated in Fig. 8. This is available with plunger diameters of 5 mm. to 9 mm., the stroke being 7 mm., while the maximum output per stroke varies from 42 cub. mm. to 168 cub. mm. The general arrangement of this pump is similar to that of the previous models. One of the principal points of difference is the use of a flat base fixing, which provides better location and avoids the wear which sometimes occurs owing to slackness. Thus alignment is conserved and the bearing life improved. The camshaft is larger in diameter than before and is therefore stiffer, a point which is of importance in view of the heavier duty.

The tappets, which are used to phase the pump by bringing the fuel injection points of the plungers into unison, are designed so that when the lock nuts have been slackened adjustment is readily effected by turning the lower spring plate. The screws for locating the pump barrel are arranged so that they are beneath the inspection cover which gives access to the tappets and calibration sleeves. Any slight oil seepage is thus retained inside the housing. The pump can be fitted with mechanical (flyweight) or pneumatic governors and fuel feed pumps.

The electrical exhibits on this stand include a number of generators and starters for Diesel engines, and a model which has been specially designed for oil engines of medium size on agricultural tractors and vehicles. Details of this starter have already been given in ENGINEERING but it may be mentioned that it differs from the axial and inertia-engaged types in that the pinion is brought slowly into mesh with the flywheel gearing by a fork lever which is operated by a solenoid. The solenoid also limits the current during initial engagement and puts the starter on full power when it is fully engaged.

To be continued

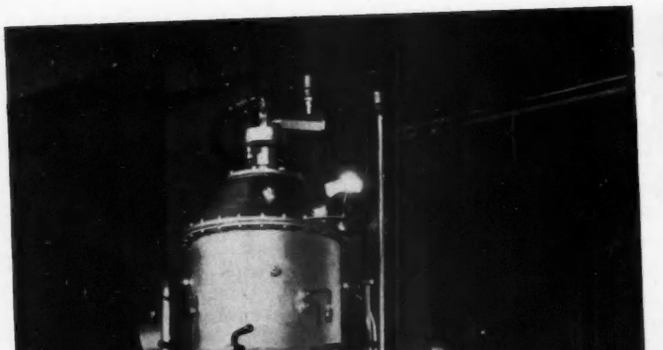


Fig. 1

Fig. 2

Figs. 1 and 2 Allen 200-h.p. simple-cycle single-shaft gas turbine, coupled to direct-current generator; a single combustion chamber, plain bearings, centrifugal impeller and radial-flow turbine are fitted.

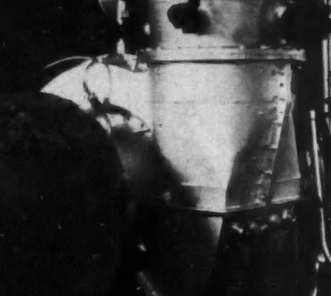

Splitter in Central Vertical Plane at Top of Inlet
One of Two Radial Spiders in Horizontal Plane
Radial Spider at Bottom of Inlet Casing
(2130.E)
"ENGINEERING"

Fig. 3 Original compressor inlet casing.

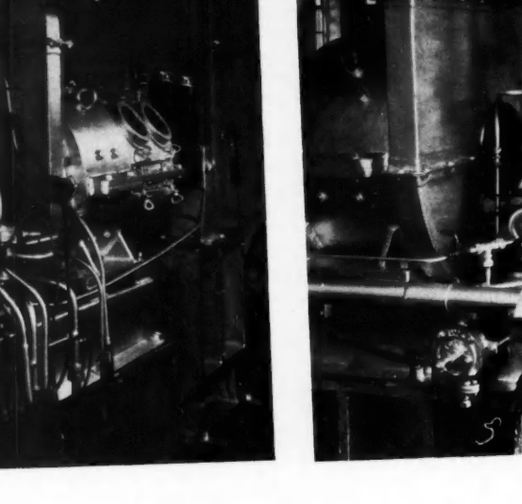
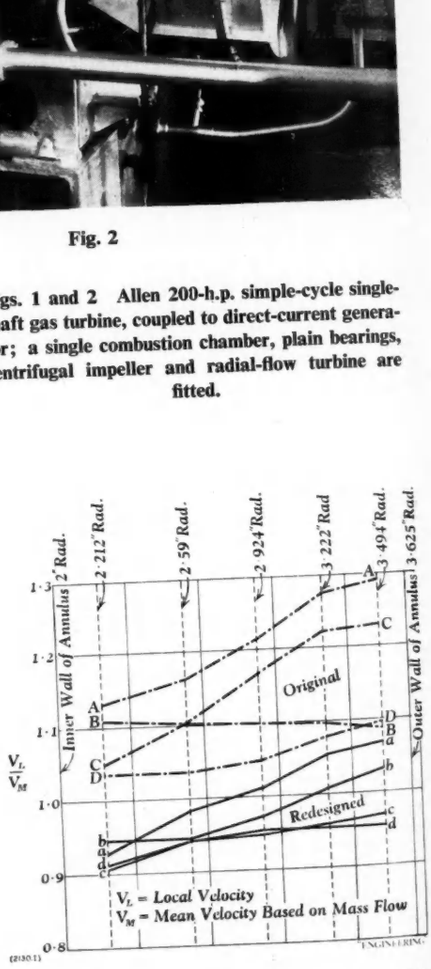


Fig. 5 Graph showing whirl in the original and redesigned compressor inlets.



Original outlet	Redesigned inlet	Circumferential station measured clockwise looking upsteam
A	a	315 deg. from top centre
B	b	45 " "
C	c	135 " "
D	d	225 " "

Fig. 7 Velocity distribution across the annuli of original and redesigned compressor inlets.

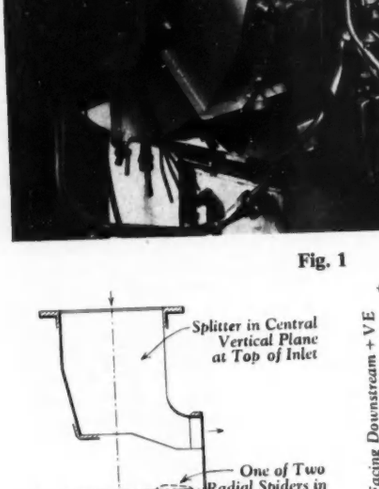


Fig. 4 Redesigned compressor inlet casing.

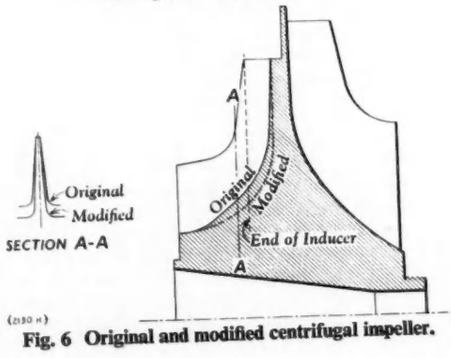


Fig. 6 Original and modified centrifugal impeller.

GAS TURBINE FOR SHIPS' EMERGENCY GENERATOR DRIVE

DEVELOPMENT OF THE ALLEN 200-H.P. UNIT

In 1950, W. H. Allen, Sons & Company, Limited, Queens Engineering Works, Bedford, in collaboration with the Admiralty, commenced preliminary design studies for a small lightweight emergency gas-turbine-driven generator for naval requirements; a contract for a 200-h.p. unit was placed with the company in August, 1951. The engine was constructed and assembled by the end of 1952, since when a comprehensive series of performance, governing and endurance tests have been carried out in the company's test house at Bedford.

Since only a limited length of running time was expected from this engine, fuel consumption and long life were relatively unimportant considerations, and it was thus possible to construct a simple cycle single-shaft type of engine. Also, to produce robustness and simplicity, the engine embodies a single-stage centrifugal compressor, a single combustion chamber and plain bearings. The compression ratio was limited to 2·5 to 1 to permit the use of a single-stage turbine.

The engine, as erected for testing and coupled to a direct-current generator, is shown in Figs. 1 and 2. The view in Fig. 1 clearly shows the single combustion chamber mounted on top of the main casing; at the far end of the generator can be seen the Rotax cartridge starter.

A radial-flow turbine was chosen for considerations of robustness, and also because in the early development stage it was thought that a radial turbine might give a higher efficiency than an axial turbine in this small size. In the design study it was found that a considerable amount of cooling air would be necessary on the disc face of the radial turbine, and hence emerged the idea of machining both the centrifugal compressor and the turbine from a single forging (Fig. 8). This idea appeared more attractive when it was determined from calculations that the cooling was so good that a ferritic steel (Rex 448) could be used. The heat transferred to the compressor gave an equivalent drop in compressor efficiency of about 1 per cent.

Originally, to avoid having a bearing in the hot exhaust gas, and to achieve the minimum overall length, the rotor was overhung, with two plain bearings running on a stationary stub shaft and the drive taken through the centre of it to the epicyclic gear. For reasons given later, the design was altered to provide a bearing on either side of the rotor, as shown in the sectional arrangement drawing, Fig. 9.

As can be seen in Fig. 9, air enters the centrifugal compressor from trunking above the set, and on leaving the diffuser it enters the main air casing which is connected to the outer annulus of a reverse-flow combustion chamber of the normal flame-tube type designed by the Shell Petroleum Company Limited. The hot gases from the combusion chamber discharge into a volute which feeds the radial turbine. The main air casing surrounds this volute, so that the only "hot" part of the engine which is exposed is the exhaust pipe.

The turbine rotor runs at a speed of 23,000 r.p.m., and drives the generator at 3,000 r.p.m. through an Allen-Stoeckicht epicyclic gear, which is contained in the main engine casing. The life of the rotor is 1,000 hours at full load.

The overall dimensions of the engine are 49¾ in. high by 39¼ in. long by 34¼ in. wide, and its weight, including reduction gear and all auxiliaries, is 600 lb. It is mounted on the extension of the generator baseplate.

The burner, of Shell design, is of the spill-type, with a constant inlet pressure of 400 lb. per sq. in. A normal oil-operated speed-control governor is fitted for maintaining the set at near constant speed (4 per cent. drop no-load to full-load) by moving a throttle in the spill line. An overspeed trip of the shock-proof unbalanced-ring type, which cuts off the fuel in the event of over running, is mounted on the fuel-pump drive shaft. The pump is a simple geared type.

CARTRIDGE STARTER

It is necessary for Naval emergency gas turbines to start quickly, and to be self-contained; a Rotax cartridge starter was therefore fitted, and has proved to be very satisfactory in operation. It has two 750-gram cartridges firing on to a small turbine wheel, and the speed of the main rotor is taken up to 9,000 r.p.m. in 3 seconds. The set then pulls away up to full speed, when it comes under the control of the governor. The rate of this acceleration and the speed-control adjustment of the governor is obtained by adjusting the blow-off pressure of the pump relief valve. A device will be fitted to prevent over-fuelling of the engine and consequent over-heating. Ignition is achieved in one of two ways – either with a simple sparkler firework, inserted by hand through a port in the combustion chamber, a method which has proved to be 100 per cent. reliable, or with a Napier-Plessey high-frequency ignition unit.

PERFORMANCE

The following is the present measured full-load performance: air inlet temperature, 60 deg. F.; output, 200-h.p.; turbine inlet temperature, 780 deg. C.; mass flow, 5·1 lb. per sec.; pressure ratio, 2·4 to 1; specific fuel consumption, 1·6 lb. per h.p. per hr.; and thermal efficiency (high-speed coupling), 8¾ per cent.

The single-shaft design makes governing easy, and the set accepts the imposition or removal of full load (200 h.p.) with a temporary speed change of only ½ per cent. in excess of the permanent speed change.

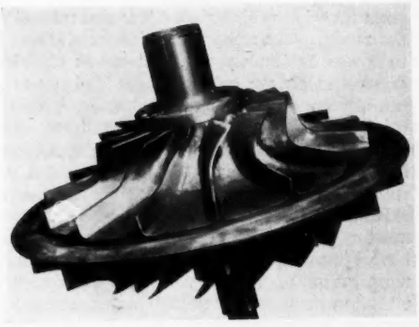


Fig. 8 Centrifugal compressor and radial-flow turbine rotor machined from a single ferritic-steel forging.

ROTOR WHIRL

The first attempt to run the engine was not entirely successful, because the amplitude of the whirl which occurred when the rotor ran up through its critical speed (7,000 r.p.m.) was so

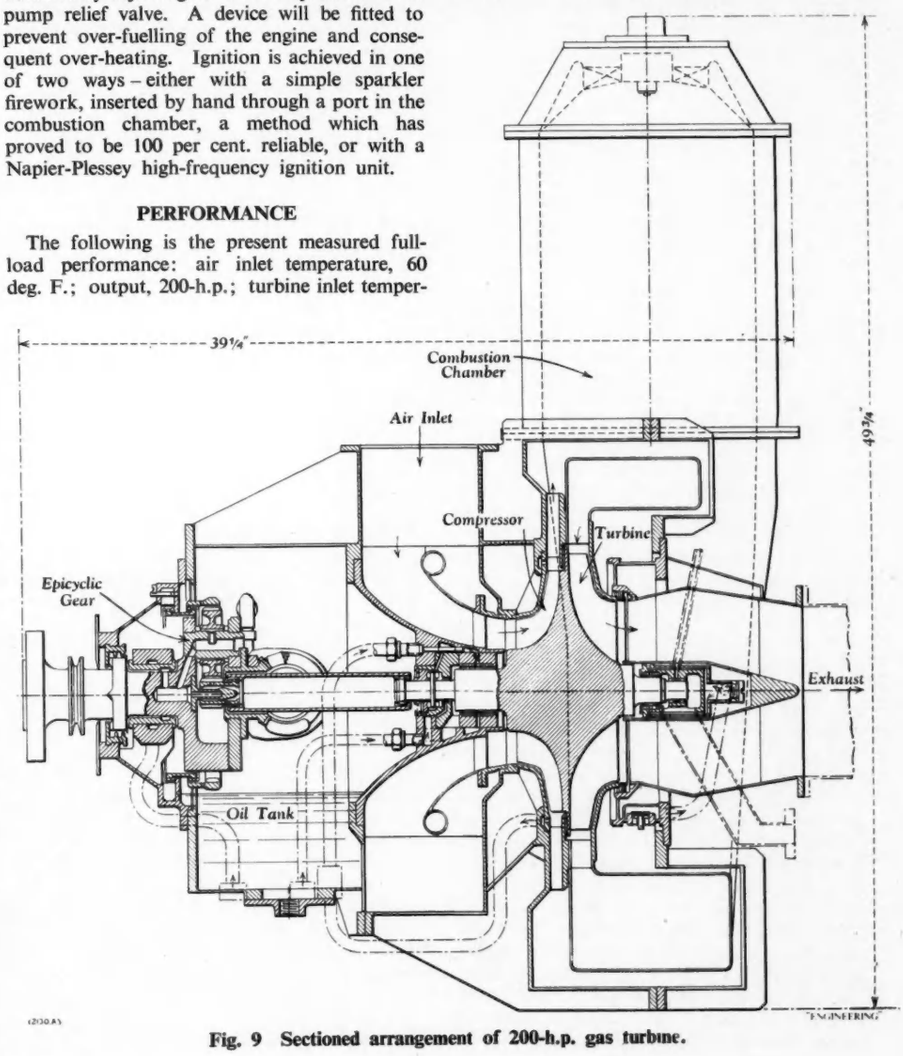


Fig. 9 Sectioned arrangement of 200-h.p. gas turbine.

great that the turbine rotor-blade tips rubbed on the casing. The reason for this excessive amplitude was not understood, and it was therefore decided to change to the present design with a bearing on either side of the rotor, with the result that the engine now runs well below its critical speed at all conditions. The initial fears for the bearing running in the hot exhaust gas stream have proved to be completely unfounded.

Running of the engine continued throughout most of 1953, and to date, well over 800 hours have been completed, mostly at a turbine inlet temperature of 730 deg. C. Apart from the vibration trouble mentioned above, there has been no mechanical defect, except to the flame tube (see below), no part has been replaced, and the growth of the rotor has been negligible.

The efficiency of the radial turbine has been established as 86 per cent., but it is not superior to an axial turbine of this size.

The combustion chamber was first tested on an atmospheric rig by Ricardo Limited and, later, developed by the Shell company on a pressurised rig to meet the design conditions of the engine. When engine running commenced, some minor alterations to the settings of components were necessary to allow for differences between the design conditions for the engine and its actual running conditions. Distortion and cracking between the mixing-air holes of the flame tube was cured by introducing an axial air bleed just upstream of these holes. After 750 hours' running, the revised flame tube remained in excellent condition. On a compact unit of this type, the air entry to the combustion chamber is necessarily constricted and asymmetrical; this has had an adverse effect on the temperature distribution at the combustion-chamber outlet. Work on this is continuing.

COMPRESSOR INLET AND IMPELLER MODIFIED

At a turbine-inlet temperature of 730 deg. C., the horse-power obtained initially was only 123, and necessitated a considerable amount of work on ways and means of increasing this output. It was soon clear that the compressor was the cause of the trouble, since both the mass flow and the pressure ratio were below design value. The first move was to open up the diffuser throat area, which made no difference at all. Attention was then focused on the main air casing, in which quite high air velocities were discovered. At the top, just leading into the combustion chamber, air was flowing in the reverse direction to that expected, apparently passing around the back of the combustion chamber from one side and re-entering the air casing on the other. Some baffles were therefore put in the casing, roughly dividing the flow from the diffusers into four streams, each feeding a quarter of the combustion-chamber air-inlet annulus. The power improvement was, however, negligible.

Consideration was next directed to the compressor inlet, shown in Fig. 3, and the inlet casing was tested. It was found that conditions were very bad as there was considerable breakaway behind two side support struts which were just in front of the impeller, and angles of whirl up to 20 deg. were measured. The air was, therefore, obviously not entering the impeller axially, and the degree of whirl represented the angle of incidence on the impeller inlet vanes. Tests were made an a modified inlet casing, and the one shown in Fig. 4 was found to be satisfactory, the maximum angle of whirl having been reduced to 4 deg. As can be seen, the approach annulus has been lengthened, and a number of radial plates provided to ensure that the tendency for the air to whirl at the sides is destroyed. The vanes at the sides were curved upward at the inlet. A cascade of zero-incidence blades was also placed at the entrance to the impeller, but it is doubtful if these are necessary, as without them the maximum incidence (or whirl) was 7 deg. Fig. 5 shows both the old and the new whirl distributions, and Fig. 7 the old and new velocity profiles.

When tried on the engine the new casing gave disappointing results, as the output was increased by only 7 h.p. to 130 h.p., but it may be that the value of this modification was not felt until later when the impeller itself had been altered. It seemed clear that the cause of the trouble was in the impeller itself, and that there was insufficient flow area in the passages. The modifications shown in Fig. 6 were then made, i.e., the disc profile was altered to allow an increase of flow area, and the vanes were thinned. This brought a marked improvement in power output of some 25 h.p. to 155 h.p. It was not possible to go further with this line of thought with the present impeller. It was then found that the power could be increased to 165 h.p. by increasing the rotational speed from 22,000 to 23,000 r.p.m. Previously, this speed increase gave no power increase. The impeller inlet ears were unbent a little, giving a slight increase in entry throat area and a few degrees of positive incidence. This had only a small effect, the power output rising to 170 h.p.

Following the completion of 750 hours' running at 730 deg. C. turbine-inlet temperature, with a negligible growth in rotor dimensions, it was decided to increase the turbine-inlet temperature and endurance running at 800 deg. C. is now underway at a power output of 212 h.p. Development is still continuing, and a new rotor with a modified impeller shape is to be fitted.

350-KW GAS TURBINE UNDER CONSTRUCTION

A larger gas-turbine of similar type to the 200-h.p. unit has also been designed and is in course of construction. This larger version is being incorporated in six complete Allen gas-turbine-driven direct-current generating sets which have been ordered by Alfred Holt and Company for auxiliary use on board Blue Funnel liners, the rating being 350 kW at an air inlet temperature of 85 deg. F. (30 deg. C.). These sets are too large to make efficient use of a radial-flow turbine, so the single-stage centrifugal impeller is driven in each case by a two-stage axial turbine. The design arrangements of this larger size of unit are shown in the sectional drawing illustrated in Fig. 10.

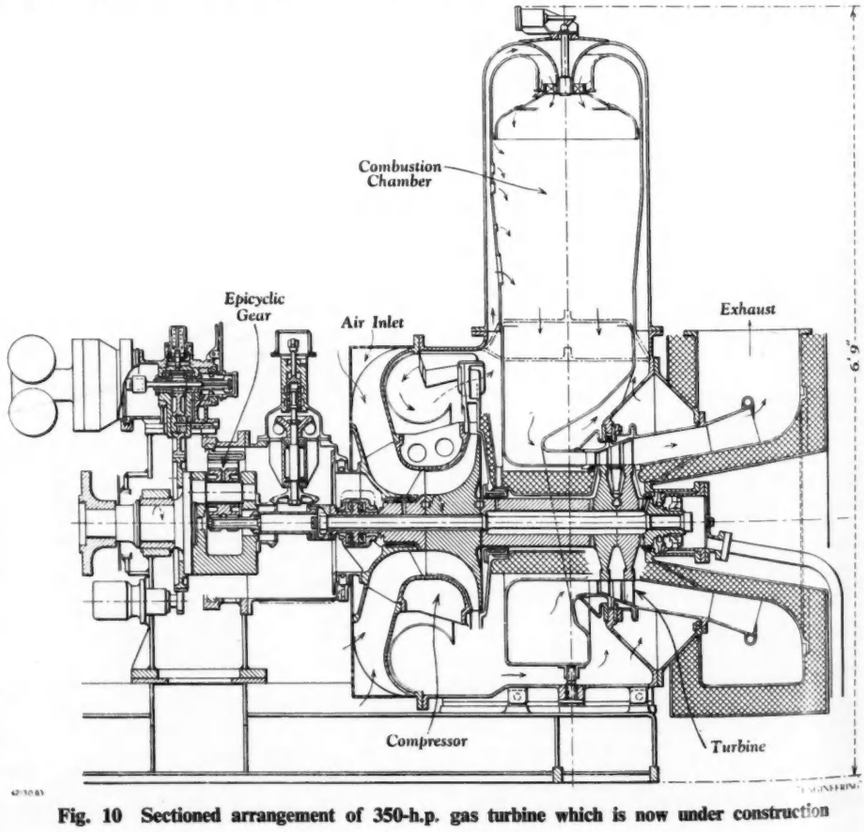


Fig. 10 Sectioned arrangement of 350-h.p. gas turbine which is now under construction

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ROAD RESEARCH LABORATORY

An exhibition was held at the Road Research Laboratory, Harmondsworth, on Wednesday, May 5, to Friday, May 7, to show representatives from local authorities the work being done there on materials and methods for road construction. The work of the Laboratory on traffic control and road safety, except in as much as they are determined by the condition of the road surface, was not represented in the exhibition.

Over a thousand accepted invitations to visit the exhibition which was designed to demonstrate the part that scientific investigation and control can play in cheapening and improving road maintenance and construction. The exhibition was a direct outcome of the policy, recommended last year by the Select Committee on Estimates, that the work of the Laboratory should be made more widely known.

There were four main groups of exhibits: soil mechanics, bituminous materials, concrete and special problems. Each of these was sub-divided and altogether there were some hundreds of separate exhibits. Special demonstrations included soil boring, soil stabilisation, laying a granular base, the treatment of joints in concrete roads and skidding tests. Films to be shown deal with soil-cement stabilisation, surface dressing with tar, and the use of wet aggregates. Mobile laboratories used for controlling processes in road construction were on view.

Labour Notes

NATIONALISATION PLANS FOR ENGINEERING

Proposals for the establishment of development councils as a means of obtaining the public control of other British industries, while, at the same time, avoiding the perils of complete nationalisation, are under consideration by the General Council of the Trades Union Congress. Inquiries regarding the working of development councils have already been instituted by the General Council among trade unions in those industries where such bodies are in operation or have functioned in the past.

In its half-yearly progress report, *What the T.U.C. is Doing*, published last Monday, price 6*d*., reference is made to the attitude of the Confederation of Shipbuilding and Engineering Unions to the nationalisation of the engineering industry.

Delegates to the annual congress of the T.U.C. last September were promised that the General Council would hold further discussions with the engineering unions on the future of various sections of the industry. An invitation to the Confederation to meet representatives of the T.U.C. was duly sent in October, but there has been no reply.

Last year, it may be recalled, the Confederation drew up some suggestions of its own for the future of the industry and published them under the title of a *Plan for Engineering*. These proposals were considerably more drastic than those of the T.U.C. and called for the eventual nationalisation of the entire industry.

CONFEDERATION'S ATTITUDE

At last year's congress, the General Council's views on the prospects for the public ownership of the engineering industry were subjected to considerable criticism, and the delegates eventually decided that there should be consultations with the Confederation before final decisions were taken with respect to the machine-tool, mining-machinery, and aircraft-constructing sections.

In spite of its own programme, as outlined in the *Plan for Engineering*, the Confederation appeared willing to co-operate with the General Council, but it is understood that, at a later date, a special sub-committee of the Confederation considered the General Council's proposals and decided that no useful purpose would be served by pursuing the question further at the present time.

Referring in its report to the invitation to the Confederation to discuss the public ownership of the engineering industry, the General Council states that it has not been the practice of the T.U.C. to proceed with schemes for the re-organisation of industries without the aid and advice of the unions whose members are employed in them. Nevertheless, no reply had been received up to the time of going to press.

GOVERNMENT'S POLICY ON CIVIL AVIATION CONDEMNED

An attack is made in the progress report on the Government for their attitude to the civil-aviation and electricity-supply industries.

On civil aviation, the General Council comment that British European Airways and the British Overseas Airways Corporation have won for themselves a high reputation on the world's air routes and complain that the Corporations are being undermined by stealth. The General Council's main ground for dissatisfaction appears to be that the publicly-owned airlines are "frozen out" of contracts for carrying troops, with the result that some 300 maintenance men at Treforest, who are engaged on overhauling the engines of B.O.A.C. Hermes aircraft, are threatened with redundancy.

When the position was realised, the General Council states, spokesmen of the T.U.C. and the unions representing the Corporations' employees met the Minister of Transport and Civil Aviation and protested vigorously that, if the Corporations were not allowed to compete on equal terms with private operators, they might be forced, owing to the undercutting which would arise, to lower their standards of safety for passengers and the working conditions of their employees.

To remedy the position, the General Council urge that the Government should stop giving regular air trooping contracts exclusively to private operators and take quick action to alleviate the unhappy situation at Treforest.

The General Council objects to the suggested establishment of two independent electricity boards in Scotland and agrees with the unions representing employees in the electricity-supply industry that this constitutes a threat to the wages and working conditions of their Scottish members.

B.O.A.C. "HERMES" AIRCRAFT MAY RETURN TO SERVICE

Hermes airliners, which have been the cause of a labour dispute at London Airport, may shortly be used by the British Overseas Airways Corporation on one of their African routes, according to an announcement made by Sir Miles Thomas, M.I.Mech.E., the Corporation's chairman, on Monday. A final decision, Sir Miles said, was likely to be made within the next few days.

It was possible that some of the Hermes aircraft might be employed on tourist services between London and Central Africa. Argonaut aircraft at present being used on these services would then be transferred to the Johannesburg route.

Owing to the recent suspension of Comet airliners, the Corporation was in need of additional aircraft on its African routes, on which traffic was increasing.

The Hermes airliners mentioned by Sir Miles are those referred to by the T.U.C. in its progress report. Nineteen of these aeroplanes were concerned in the dispute at London Airport. Maintenance men employed there refused to handle the aircraft. The men alleged that the sale of the airliners to private companies would result in these aeroplanes being brought into competition with the Corporation, and that the employment of some of the Corporation's staff might thereby be endangered.

The dispute respecting ten of the Hermes aircraft, which had been sold by the Corporation to Messrs. Skyways, Limited, was brought to an end on May 8, but a decision on the other nine was postponed.

AMALGAMATED ENGINEERING UNION IN CONFERENCE

As was to be expected, comments on the recent wage negotiations in the engineering industry were made by Mr. R. Openshaw, the newly-appointed President of the Amalgamated Engineering Union, in his address at the opening of the annual conference of the union's national committee at Blackpool on May 3. This committee is the body which determines the policy to be pursued by the union during the ensuing twelve months.

The union, in company with the other organisations affiliated to the Confederation of Shipbuilding and Engineering Unions, had requested an all-round increase of 15 per cent. on the wages of its adult male members. Subsequent negotiations on the claim, following the report of the engineering Court of Inquiry, resulted in advances of 8*s*. 6*d*. a week for skilled operatives, 7*s*. 6*d*. a week for semi-skilled men, and 6*s*. 6*d*. a week for labourers.

Engineering employers, Mr. Openshaw said, had expressed a wish that there should be a period in the industry free from the uncertainties and disruptions caused by further wage claims. For himself, he would not be averse to such a course. He knew the difficulties of contracting for orders with the possibility that, before the contract was completed, the price might have to be changed, perhaps more than once, owing to advances in wages.

An end to wage negotiations would have the additional advantage of giving the unions an opportunity to secure satisfaction on many other questions and grievances, such as the revision of the industry's disputes procedure and the completion of a comprehensive wage structure.

CO-OPERATION WITH EMPLOYERS TO REDUCE LIVING COSTS

What workpeople wanted, Mr. Openshaw suggested, was not so much more money to spend, as the ability to purchase an increased amount of goods and amenities with the sums they received. On this account, he would like to see the employers' organisations co-operating with the unions in endeavours to reduce living costs.

These organisations could take steps to prevent the continual rise in the cost of living by instituting voluntary schemes for the stabilisation of prices. Should the employers adopt such an attitude of determination to fix prices to the consumer, and then to reduce them, the union would feel far happier about emphasising the need for restraint in demands for higher wages and in co-operating with the employers to secure increased productivity in the engineering industry.

Turning to the work of the Confederation of Shipbuilding and Engineering Unions, Mr. Openshaw asked the rank-and-file members of the 39 bodies affiliated to that organisation to bring pressure to bear on their individual unions to work for the amalgamation of all, or some, of those associations into a single strong united organisation.

He said that in the Confederation, with its 39 separate unions, much time and effort were spent in preparing a unified policy. If, however, the Confederation were a single integrated union, efforts on behalf of engineering and shipbuilding employees would be simpler, quicker and more efficient.

Arrangements could be made to protect the interests of special classes of operatives in the new organisation, just as there existed special groups in the Amalgamated Engineering Union.

LACK OF AGREEMENT ON RAILWAY WAGES

In his address to delegates at the annual conference of the goods and cartage grades of the National Union of Railwaymen, at Great Yarmouth on May 9, Mr. S. F. Greene, the senior assistant general secretary of the union, stated that, so far, the union had been unable to reach an agreement with the British Transport Commission on the question of a basic minimum wage for the conciliation staffs of British Railways.

Although there might be some disappointment at this present failure to agree, there was no need for despair. There was certainly no need at the moment, Mr. Greene emphasised, for anyone to suggest the taking of industrial action to enforce the union's point of view.

It was the firm intention of the union, in accordance with the undertaking it had given, to carry on its negotiations with the Commission for a sensible wage structure in the industry.

THE IRON AND STEEL INSTITUTE

Annual General Meeting

The eighty-fifth annual general meeting of the Iron and Steel Institute will be held on Wednesday and Thursday, May 26 and 27. The morning session on the first day will take place in the lecture theatre of the Royal Institution, Albemarle-street, London, W.1. The remainder of the meeting will be held at the offices of the Institute, 4 Grosvenor-gardens, London, S.W.1.

The meeting opens at 9.45 a.m., on the first day, when formal business will be transacted. The retiring President, Mr. James Mitchell, C.B.E., will then induct the new President, the Hon. R. G. Lyttelton, who will deliver his presidential address. The remainder of the morning will be devoted to the reading of the seventh Hatfield Memorial Lecture, on "Development in the Iron and Steel Industry in Great Britain during the last Twenty-five Years," by Dr. T. P. Colclough, C.B.E.

At the afternoon session of May 26, at 2.30, two papers will be presented for discussion, namely, "Soaking-Pit Practice at the Normanby Park Steelworks of John Lysaght Ltd.," by Mr. A. H. Norris, and "Some Factors Affecting the Wear of Graphite Electrodes in the Electric-Arc Furnace," by the Electric Process Sub-Committee of B.I.S.R.A. In the evening a members' dinner will be held.

On Thursday, May 27, two sessions will be held. At the morning session commencing at 10 a.m., seven papers will be presented for joint discussion. They are: "Eutectic Solidification in Grey, White, and Mottled Hypo-Eutectic Cast Irons," by Professor A. Hultgren, Mr. Y. Lindblom and Professor E. Rudberg; "Structural Changes during Annealing of White Cast Irons of High Sulphur-Manganese Ratios," by Professor A. Hultgren and Mr. G. Ostberg; "The Growth of Nodular Graphite," by Mr. M. Hillert and Mr. Y. Lindblom; "The Solidification of Nodular Iron," by Mr. H. Morrogh; "Undercooled Graphite in Cast Irons and Related Alloys," by Mr. H. Morrogh and Mr. W. J. Williams; "Solidification in Iron-Phosphorus-Carbon Alloys," by Mr. H. Morrogh and Mr. P. H. Tütsch; and "Decomposition of Cementite during Solidification of Cast Iron," by Dr. A. Berman and Dr. V. Kondic.

In the afternoon, at 2.30, there will be joint discussion on four papers, namely, "New Swedish Mill Designs and Layouts for Medium and Small Sections and Wire-Rod," by Mr. S. E. M. Norlindh; "The New Fagersta Wire-Rod Mill," by Mr. K. E. Pihlblad; "Roller Bearings in Swedish Rolling Mills and the SKF Rolling-Mill Design," by Mr. A. Leufven; and "Practical Experience in the Use of Repeaters in a Looping Mill," by Mr. H. W. Riddervold.

AWARD OF MEDALS AND PRIZES

During the first morning session on May 26, the following medals and prizes will be presented.

The Bessemer Medal for 1954 will be handed to Dr. T. P. Colclough, C.B.E., technical adviser to the British Iron and Steel Federation, in recognition of his contributions to the development of the manufacture of iron and steel.

The Sir Robert Hadfield Medal for 1954 will be presented to Dr. A. H. Leckie, technical officer to the Iron and Steel Board in recognition of his contributions to research in steelmaking.

The Andrew Carnegie Silver Medal for 1953 will be given to Mr. G. R. Bish, of Enfield Cables Limited, for his report, written in conjunction with Professor H. O'Neill who was not eligible, on "The Deformation of Austenite in Relation to the Hardness Characteristics of Steel."

Williams Prizes for 1953, will consist of two, each of £100; one is to be presented to Mr. A. H. Norris, of John Lysaght Limited, Scunthorpe, and the other to Mr. E. R. S. Watkin, of Appleby-Frodingham Steel Company. The Ablett Prize for 1953, will be handed to Mr. F. Starkey, of Buckley and Taylor Limited, Oldham.

LAUNCHES AND TRIAL TRIPS

S.S. "GEORGIDORE."—Single-screw cargo vessel, built and engined by John Readhead & Sons, Ltd., South Shields, for the Maritime Shipping and Trading Co., Ltd., London, E.C.3. Main dimensions: 430 ft. between perpendiculars by 59 ft. by 38 ft. 6 in. to upper deck; deadweight capacity, 11,400 tons on a draught of about 28 ft. 6 in. Triple-expansion steam-reciprocating engine, working in conjunction with a Bauer-Wach exhaust turbine and three oil-fired boilers. Service speed, 12½ knots. Trial trip, April 8.

M.S. "BRITISH SERGEANT."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 490 ft. between perpendiculars by 65 ft. by 36 ft.; deadweight capacity, 14,000 tons. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston Diesel engine. Launch, April 14.

M.S. "BRITISH CHANCELLOR."—Single-screw oil tanker, built by the Blythswood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 515 ft. by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, about 16,000 tons. Barclay Curle-Doxford six-cylinder two-stroke opposed-piston oil engine, developing 6,900 b.h.p., constructed by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow. Launch, April 21.

M.S. "SOLSTEN."—Single-screw oil tanker, built and engined by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for Rafen and Loennechen, Tönsberg, Norway. Sixth vessel built for these owners. Main dimensions: 528 ft. by 65 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, about 15,200 tons; gross tonnage, about 10,300. Barclay Curle-Doxford five-cylinder opposed-piston oil engine. Launch, April 23.

NOTICES OF MEETINGS

Institute of Fuel

BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Thurs., May 27, 6 p.m.

Institute of Marine Engineers

LONDON
Films: "Power for Ships" and "Diesel Power on the River Thames." Junior Section. Mon., May 17, 6.30 p.m.
"Watch-Keeping and Sea-Going Practice," by H. C. Gibson. Junior Section. Mon., May 31, 6.30 p.m.

Institute of Petroleum

LONDON
"Medical Services in the Petroleum Industry." Symposium. Papers presented by S. D. McClean and F. L. Webster. Wed., May 19, 5.30 p.m.

Institution of Chemical Engineers

BIRMINGHAM
"Application of Plastics in Chemical Engineering." Discussion. Midlands Graduates' and Students' Section. Chemical Engineering Department, Birmingham University, Edgbaston, Birmingham. Wed., May 26, 11 a.m.

Institution of Civil Engineers

LONDON
"Design and Construction of the Superstructure of the Marshal Carmona Bridge at Vila Franca de Xira, Portugal," by T. J. Upstone and W. Cardno. Structural and Building Engineering Division. Tues., May 18, 5.30 p.m.
"The Road Surface as a Factor in Street Lighting," by A. W. Christie. Road Engineering Division. Thurs., May 20, 5.30 p.m.
"Owen Falls, Uganda Hydro-Electric Development: General Aspects," by Sir Charles Westlake, T. A. L. Paton and R. W. Mountain. Joint Meeting with the Institution of Electrical Engineers. Tues., May 25, 5.30 p.m.
"Owen Falls: Constructional Problems," by D. P. Bertlin and Henry Olivier. With a note on "Model Tests," by Professor C. M. White. Supplementary Meeting. Wed., May 26, 5.30 p.m.
"Development and Utilisation of Hydro-Electric Power in Uganda," by Sir Charles Westlake, J. M. Stock and J. C. Lithgow. Joint Meeting with Institution of Electrical Engineers. At the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Thurs., May 27, 5.30 p.m.

Institution of Electrical Engineers

LONDON
Annual General Meeting and Film Evening. London Students' Section. Mon., May 17, 6.30 p.m.
Questions Night. Education Discussion Circle. Tues., May 18, 6 p.m.
Annual General Meeting of the Institution. Corporate Members and Associates only. Thurs., May 20, 5.30 p.m.
"Owen Falls, Uganda Hydro-Electric Development: General Aspects," by Sir Charles Westlake, T. A. L. Paton and R. W. Mountain. Joint Meeting with the Institution of Civil Engineers. At the Institution of Civil Engineers, Great George-street, S.W.1. Tues., May 25, 5.30 p.m.
"Electrical Power Demand and Supply in the United States and the Role of Research in the Quarter Century Ahead," by Philip Sporn. Supply Section Annual Lecture. Wed., May 26, 5.30 p.m.
"Development and Utilisation of Hydro-Electric Power in Uganda," by Sir Charles Westlake, J. M. Stock and J. C. Lithgow. Joint Meeting with the Institution of Civil Engineers. Thurs., May 27, 5.30 p.m.

Institution of Mechanical Engineers

BIRMINGHAM
"Brakes," by G. J. H. Buss. Midland Graduates' Section. James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Mon., May 17, 7 p.m.
James Clayton Lecture on "Nuclear Reactors and Power Production," by Sir Christopher Hinton. Midland Branch. Thurs., May 20, 6 p.m.

Institution of Mining and Metallurgy

LONDON
Annual General Meeting, 4 p.m. (Open to members and non-corporate members of the Institution only.) Presidential Address by Brigadier R. S. G. Stokes, 5.15 p.m. (Open to members and visitors.) Geological Society's Apartments, Burlington House, Piccadilly, W.1. Thurs., May 27.

Institution of Production Engineers

SHREWSBURY
"Cutting Tools: Their Development and Application," by W. Castledine. Shrewsbury Section. Shrewsbury Technical College, Shrewsbury. Wed., May 26, 7.30 p.m.
STOKE-ON-TRENT
"Metal Spraying," by H. J. Plaster (with film). Stoke-on-Trent Section. Building Department, North Staffordshire Technical College, Cauldon-place, Shelton, Stoke-on-Trent. Fri., May 21, 7.30 p.m.
WOLVERHAMPTON
"The Metallurgist's Place in Production Engineering," by E. R. Gadd. Wolverhampton Graduate Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Thurs., May 20, 7.30 p.m.

Institution of Structural Engineers

LONDON
Annual General Meeting. Thurs., May 27, 6 p.m.
PLYMOUTH
Annual General Meeting. South-Western Counties Branch. Duke of Cornwall Hotel, Plymouth. Fri., May 21, 7 p.m.

Royal Aeronautical Society

LONDON
"The Choice of Power Units for Civil Aeroplanes," by Dr. A. E. Russell. 42nd Wilbur Wright Memorial Lecture. Royal Institution, Albemarle-street, W.1. Thurs., May 20, 6 p.m.

Royal Institution

LONDON
"Britain's Giant Radio Telescope," by Professor A. C. B. Lovell. Fri., May 21, 9 p.m.

Royal Meteorological Society

LONDON
"Observations of Rainfall from Warm Clouds," by W. A. Mordy and L. E. Eber; "Turbulence in Clouds as a Factor in Precipitation," by T. W. R. East and J. S. Marshall; and "The Terminal Velocity of Snow Flakes," by M. P. Langleben. Wed., May 19, 5 p.m.

The Royal Society

LONDON
"Soil Metabolism," by J. H. Quastel. Leeuwenhoek Lecture. Fri., May 28, 4.30 p.m. (Postponed from May 6.)

Royal Society of Arts

LONDON
"Engineering Developments in Central Africa," by Sir William Halcrow. Tues., May 18, 5.15 p.m.

Royal Statistical Society

LONDON
"Non-Response and Clustering in Sample Surveys: An Experimental Study," by J. Durbin and A. Stuart. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., May 19, 5.15 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting. Manson House, 26 Portland-place, W.1. Tues., May 25, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (MONarch 2096.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Society of Instrument Technology, 55 Tudor-gardens, London, W.3.